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A novel approach for risk evaluation and risk response planning in a geothermal drilling project using DEMATEL and fuzzy ANP

Alireza Ghassemi[a*] and Ayoub Darvishpour[a]

[a]*School of Industrial and Systems Engineering, College of Engineering, University of Tehran, Iran*
[b]*Department of Mining Engineering, Isfahan University of Technology, Iran*

C H R O N I C L E

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A B S T R A C T

Risk response planning is a widely concerned issue. Project managers usually struggle to control different kinds of risks. In project risk management, after evaluating risks, the final process relates to choosing desirable responses to the risks. In this paper, a comprehensive framework confronts the issue in three main phases. In the first phase, all the risks, responses and their relations in a geothermal drilling project are detected. These relations imply there are inner dependent and outer dependent relations. In the second phase, ANP, DEMATEL and fuzzy theory play important roles in weighting risks and responses. In the third phase, to enable a more realistic solution, a zero-one integer programming reflects a budget constraint and other required constraints. After obtaining the optimal responses, the effect of budget is analyzed. In addition, the influences of risks on each other are discussed more deeply. Collectively, this study offers a new perspective on how to handle project risks and choose their responses.

1. Introduction

Success of projects significantly depends on effective project risk management through risk response planning (Mousavi et al,. 2011). Actually, a project as a temporary endeavor to create unique deliverable item is faced with various unexpected barriers (Zhang & Fan, 2014). Multiple issues, such as complex technical design, different stakeholders, poor management, various resources, and changing economic/political environments may initiate uncertain conditions and events for projects that their occurrences affect project performance criteria negatively (Dey, 2002; Fan et al., 2008; Sadjadi & Sadi-Nezhad, 2017; Project Management Institute, 2013). Thus, project risk management has become a prominent topic for practitioners and researchers.

Project risk management process involves three major steps: identifying, assessing and response planning. In the first step, risks are discovered and recorded. Then, they are evaluated according on

* Corresponding author.
E-mail address: a.ghassemi.91@alumni.ut.ac.ir (A. Ghassemi)

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their main characteristics like likelihood and impact of risky events (Zhang & Fan, 2014; Nagar & Raj, 2012). Risk evaluation is a challenging job under vast uncertainty involved in the project (Shariati, 2014). In order to prevent undesirable occurrences, the decision makers select and implement adequate actions as risk responses (Zhang & Fan, 2014). In addition, only an organized manner from the project planning phase through the end of the project is able to resolve concerns about risks (Ebrahimnejad et al., 2012). In a sense, project risk identification and assessment are useless without developing, selecting and implementing responses. The main concern is how to select the most favorable response actions among a pool of various response plans (Gonen, 2012).

According to Ward and Chapman (2003), responses are categorized into four types: avoidance, transference (to the third party), mitigation and acceptance. Except avoidance, the other types of response strategies are costly and require money to be implemented. In contrast, the allocated budget to risk management is limited. Hence, decision makers must choose the proper risks to be handled and the optimal responses to be planned that will not cross budget limit (Gonen, 2012).

In practice, the interactions and synergies between risk responses play important roles in the risk response planning. However, most studies have not paid attention to this issue (Soofifard & Bafruei, 2016). Concerning distinct characteristics of risks in risk management, earlier attempts to deal with this problem have usually assumed the risks independently. But, project risks often depend on each other and reciprocally affect (Zhang, 2016; Ackermann et al., 2007; Kwan & Leung, 2011).

Due to difficulty and various aspects of impacts in risk management structure, application of multi-criteria decision making to catch the best strategies and move forward into project success is helpful. The structure establishes a network and should be handled by Analytical Network Process (ANP) approach. Also, interdependencies between factors (risks or responses) lead us to utilize related tools such as Decision-making trial and evaluation laboratory (DEMATEL). Further, because of inaccurate expert opinion, fuzzy concepts could improve the transparency in data collection (Soltannezhad Dizaji et al., 2018).

The aim of this paper is to construct a model for responding to a geothermal drilling project risks. The model includes three phases: in the first phases, risks and their responses will be evaluated in a network structure, and the second phase will choose the best actions based on response weights achieved from the previous phase.

In the following, related papers are investigated to analyze gaps among previous findings of the authors. The next section will provide comprehensive descriptions about applying decision making methods, then the mathematical model will be introduced. We examine a real case study in the fifth section to verify the model performance. The paper finishes with a conclusion and some suggestions for further researches.

2. Related Literature

Since four decades ago, risk management studies have tried to understand how to respond the risks threatening projects. Responding to project risks has been addressed by Chapman (1979) for the first time. After introducing a systematic approach to analyzing, evaluating and responding to risks by Chapman (1979), researchers utilized response strategies by qualitative methods, without using mathematical models. However, in recent years, new investigations used mathematical models for solving the problem. In Table 1, most comprehensive and important studies are summarized.

Based on the number of criteria, three main groups of papers are more frequent: (I:) cost-based approaches, (II:) models concerning project performance criteria (cost, time, quality and etc.) and (III:) qualitative methods which generally do not tackle the problem from criteria view, or they reflect unlimited number of criteria.

Table 1
Literature Review

Authors	Main focus	Criteria
(Ben-David et al., 2002)	Representation of a mathematical model which allows the overlapping effects of multiple response actions and considers the impacts of secondary risk events	Cost
(Kujawski, 2002)	Viewing the issue as a portfolio theory problem and generating efficient set of responses by trade-off between project cost vs. probability of success	Cost
(Fan et al., 2008)	Proposing a conceptual framework that defines the quantitative relationship between risk-handling strategy (prevention and adaptation) and relevant project characteristics (e.g., project size, slack, or technical complexity)	Cost
(Gonen, 2012)	Allocating a risk management budget among the possible mitigation or transfer plans regarding response feasibility	Cost
(Fang et al., 2013)	Analyzing risk propagation behavior to anticipate the overall effects of response actions on the global risk network under budget constraint	Cost
(Zhang 2016)	An approach to quantitatively calculating the interdependencies of the risks in two directions based on precedence of the risks and the effects on responses	Cost
(Klein, 1993)	Utilizing three complementary approaches (cognitive mapping, contingency-response analysis, risk-level) to conceptualizing and modelling risk trade-offs	Cost, Time and Quality
(Nik et al., 2011)	Integrating the project work breakdown structure (WBS), risks, responses and their effects into a practical framework	Cost, Time and Quality
(Zhang & Fan, 2014)	Iterative process by the project manager who makes trade-offs between three critical elements of the project (cost, schedule, quality)	Cost, Time and Quality
(Soofifard & Bafruei, 2017)	Offering positive or negative synergism between responses and balancing the selected responses based on their prerequisites and requisites relations	Cost, Time and Quality
(Seyedhoseini et al., 2009)	Minimizing the undesirable deviation from achieving the project scope during an iterative planning process methodology and combining results with project planning	Cost, Time, Quality, Scope
(Samadi et al., 2014)	Proposing a framework respect to multi-dimensional nature of the project risks in a network and respond to highly prioritized risks	Cost, Time, Quality, Scope
(Klein et al. 1994)	Assessing risk related to a prototype activity in order to save time, expense and effort spent on risk analysis	Qualitative
(Motaleb & Kishk, 2014)	Surveying the effectiveness of maturity in organization, project management and systems for evaluating the risk responses	Qualitative
(Kuchta & Skorupka, 2014)	Considering various levels (based on closeness or manageability or accessibility or etc.) and several attributes (like probability, consequences and etc.) of risks to evaluate risks in a mathematical programming model before and after the implementation of the model	Qualitative

In the first group, models are emphasizing on minimizing cost or maximizing profit or both. These models are implementing the actions to lessen the total cost of project risks. Costs include the deterministic costs and the expected costs (Raz, 2001), that after applying response actions, the deterministic costs decrease and the expected costs increase. Project costs could prevent the occurrence of a risk and cut its probability, or adapt with the risk and diminish its impact, or in the third application, reduce the probability and the impact simultaneously by a combined strategy (Fan et al., 2008). If the objective functions do not focus on the cost or profit, budget constraint could be useful (Kayis et al., 2007).

In the second group, there are some models which lean on the performance criteria of the project. These criteria could place beside each other to form a multi-objective problem, then by weighting each objective, efficient solutions set will be achieved (Rezaee Nik et al., 2011). Although, the performance criteria may not be seen in objectives and be considered in constraints instead (Zhang & Fan, 2014).

The third group is models which do not have limitation in number of criteria. In addition to the mentioned criteria, customer satisfaction and other factors are suggested in the (Kuchta & Skorupka, 2014) model as indexed variables which each index belongs to a criterion.

Previous papers have not considered interdependencies between risks. Another major gap is about involving every four types of responses. Also, secondary risks have not attracted much attention in earlier studies. In this paper, we develop an integrated model to fill these gaps.

3. Preliminaries

3.1. Fuzzy PCM

Decision makers always deal with qualitative evaluations between factors. The importance of factors should be compared with each other by multi criteria decision making techniques. The primary tool for interpreting data is pairwise comparison matrix (PCM). A PCM is formed to compare a pair or more pairs of factors with respect to a reference factor. Meanwhile, obtained data from decision makers are often uncertain, subjective and imprecise. This challenge creates a complex condition in decision making process which leads managers to handle uncertain data by means of fuzzy theory (Deng, 1999). Fuzzy theory concept confronts subjectivity in judgements by converting linguistic data to fuzzy numbers (triangular, trapezoidal and etc.). In this paper, the conversion scale for converting linguistic judgments to triangular fuzzy numbers (TFN) is prepared for six assessment grades, shown in Table 2.

Table 2
Triangular fuzzy conversion scale (Chang 1996)

Linguistic scale	Triangular fuzzy conversion scale	Triangular fuzzy reciprocal scale
Just Equal	$(1, 1, 1)$	$(1, 1, 1)$
Equally Important	$(2/3, 1, 2)$	$(1/2, 1, 3/2)$
Weakly More Important	$(1/2, 2/3, 1)$	$(1, 3/2, 2)$
Moderately More Important	$(2/5, 1/2, 2/3)$	$(3/2, 2, 5/2)$
Strongly More Important	$(1/3, 2/5, 1/2)$	$(2, 5/2, 3)$
Extremely More Important	$(2/7, 1/3, 2/5)$	$(5/2, 3, 7/2)$

After performing comparisons and capturing data, TFNs are prepared in the square and symmetrical fuzzy comparison matrices as follows:

$$\tilde{A} = (\tilde{a}_{ij})_{n\times n} = \begin{bmatrix} (1,1,1) & (l_{12},m_{12},u_{12}) & \cdots & (l_{1n},m_{1n},u_{1n}) \\ (l_{21},m_{21},u_{21}) & (1,1,1) & \cdots & (l_{2n},m_{2n},u_{2n}) \\ \vdots & \vdots & \vdots & \vdots \\ (l_{n1},m_{n1},u_{n1}) & (l_{n2},m_{n2},u_{n2}) & \cdots & (1,1,1) \end{bmatrix} \tag{1}$$

where:

$$\tilde{a}_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right) = \tilde{a}_{ji}^{-1} = \left(\frac{1}{u_{ji}}, \frac{1}{m_{ji}}, \frac{1}{l_{ji}}\right) \qquad \forall i, j \tag{2}$$

stands for the importance of the item i to the item j with respect to an objective. For instance, $\tilde{a}_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right) = \left(2/5, 1/2, 2/3\right)$ means item i is *Moderately More Important* than item j with respect to their reference factor. At this stage, the weights of each factor with respect to the upper level are estimated (local weights). Therefore, the (Calabrese et al., 2013) procedure is adapted for single decision maker. Accordingly, checking the consistency has to be done. Defuzzification equation for adjusting crisp entries in comparison matrices is as follows (Wang & Elhag, 2007);

$$a_{ij}\left(\tilde{a}_{ij}\right) = \frac{l_{ij} + m_{ij} + u_{ij}}{3} \qquad \forall i \tag{3}$$

The largest eigenvalue of the comparison matrix is denoted as $\lambda_{\max}$. Also, n is the dimension of the PCM and $RI(n)$ is a random index depending on n as shown in Table 3. So the consistency index (CI) and the consistency ratio (CR) are reflecting by next formulas:

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{4}$$

$$CR = \frac{CI}{RI\left(n\right)} \tag{5}$$

If $CR \le 0.1$, the consistency of the matrix is satisfactory. Otherwise, the decision maker should try to revise matrix until the consistency is reached.

Table 3
Consistency indices for a randomly generated matrix (Saaty 1990)

n	3	4	5	6	7	8	9
$RI(n)$	0.58	0.9	1.12	1.24	1.32	1.41	1.45

After obtaining consistency, the relative row sum for PCM is calculated:

$$\widetilde{RS}_i = \sum_{j=1}^{n} \tilde{a}_{ij} = \left(\sum_{j=1}^{n} l_{ij}, \sum_{j=1}^{n} m_{ij}, \sum_{j=1}^{n} u_{ij} \right) \qquad \forall i \tag{6}$$

Then, the normalized row sum $\tilde{S}_i$ is possible to compute (Wang & Elhag 2006):

$$\tilde{S}_i = \frac{\widetilde{RS}_i}{\Sigma_{j=1}^{n} \widetilde{RS}_j} = \left(\frac{\Sigma_{j=1}^{n} l_{ij}}{\Sigma_{j=1}^{n} l_{ij} + \Sigma_{k=1,k\neq i}^{n} \Sigma_{j=1}^{n} u_{kj}}, \frac{\Sigma_{j=1}^{n} m_{ij}}{\Sigma_{k=1,k\neq i}^{n} \Sigma_{j=1}^{n} m_{kj}}, \frac{\Sigma_{j=1}^{n} u_{ij}}{\Sigma_{j=1}^{n} u_{ij} + \Sigma_{k=1,k\neq i}^{n} \Sigma_{j=1}^{n} l_{kj}} \right) = \left(l_i, m_i, u_i \right) \tag{7}$$

Ultimately, by converting fuzzy weights to the crisp weights, the local weights are indicated by the following expressions (Calabrese et al., 2013):

$$S_i\left(\tilde{S}_i\right) = \frac{l_i + m_i + u_i}{3} \qquad \forall i \tag{8}$$

$$w_i = \frac{S_i}{\sum_{i=1}^{n} S_i} \qquad \forall i \tag{9}$$

3.2. DEMATEL

DEMATEL was introduced in 1972 for the first time in order to quantitative processing of people's opinions. This method is able to identify the interdependencies between the factors of the same level in a decision making network structure, using cause-and-effect relations between the factors (Wu & Tsai, 2011; Durán et al., 2018).

First, the decision maker assigns an integer score rating in range [0,4] to address the direct influence of factor i on factor j, which is denoted by b_{ij}. Number 0 represents "no influence" and number 4 represents "very high influence". Respectively, 1,2 and 3 represent ''low influence", ''medium influence" and "high influence" (Yang et al., 2008). The initial influence matrix B is stated in the next equation (Naturally, all principal diagonal entries are equal to zero):

$$B=[b_{ij}]_{m\times m}=\begin{Bmatrix} 0 & \cdots & b_{12} & \cdots & b_{1m} \\ b_{21} & \cdots & 0 & \cdots & b_{2m} \\ \vdots & & \vdots & & \vdots \\ b_{m1} & \cdots & b_{m2} & \cdots & 0 \end{Bmatrix} \tag{10}$$

After normalizing matrix B by following equations, the initial direct influence matrix M is obtained:

$$M = k.B \tag{11}$$

$$k = \mathrm{Min}\left(\frac{1}{\max\limits_{1\le i\le m}\sum_{j=1}^{m} b_{ij}}, \frac{1}{\max\limits_{1\le j\le m}\sum_{i=1}^{m} b_{ij}}\right) \tag{12}$$

The total-influence matrix T captures every direct/indirect influence between factors:

$$T = M + M^2 + M^3 + \ldots = \sum_{i=1}^{\infty} M^i = M(I-M)^{-1} \tag{13}$$

$$T = [t_{ij}]_{m\times m} \tag{14}$$

The sum of factor i effects on the other factors, and also the sum of effects that factor j receives from the other factors are denoted by D_i and R_j:

$$D_i = \sum_{j=1}^{m} t_{ij} \qquad \forall i \tag{15}$$

$$R_j = \sum_{i=1}^{m} t_{ij} \qquad \forall j \tag{16}$$

For computing local weights, we used (Büyüközkan & Öztürkcan 2010) approach:

$$w_{ij} = \frac{t_{ij}}{\sum_{k=1}^{m} t_{kj}} \qquad \forall i, j \tag{17}$$

3.3. Limit Supermatrix

According to ANP, once local priorities are determined, the global priorities have to be measured. By entering local priority vectors into the specific columns of a larger matrix, a supermatrix is formed. As below, a supermatrix contains $N*N$ segments which each segment represents a relationship between two clusters of factors. I denote each cluster by C_k, $k=1, \ldots,$ N that cluster k contains m_k factors. The obtained local weight vectors are placed in the proper locations. The effect of the k th cluster on the j th cluster ($m_k = l$ and $m_j = u$) by means of local weights is as follows:

$$W_{kj} = \begin{bmatrix} w_{k1,\mathrm{j}1} & w_{k1,\mathrm{j}2} & \cdots & w_{k1,\mathrm{ju}} \\ w_{k2,\mathrm{j}1} & w_{k2,\mathrm{j}2} & \cdots & w_{k2,\mathrm{ju}} \\ \vdots & \vdots & \vdots & \vdots \\ w_{kl,\mathrm{j}1} & w_{kl,\mathrm{j}2} & \cdots & w_{kl,\mathrm{ju}} \end{bmatrix} \tag{18}$$

For instance, $w_{k3,\mathrm{j}4}$ shows the normalized weight of 3rd factor of the cluster k respect to 4th factor of the cluster j. Thus, the supermatrix is formed (Chang et al., 2007):

$$W = \begin{bmatrix} W_{11} & \cdots & W_{1j} & \cdots & W_{1N} \\ \vdots & & \vdots & & \vdots \\ W_{k1} & \cdots & W_{kj} & \cdots & W_{kN} \\ \vdots & & \vdots & & \\ W_{N1} & \cdots & W_{Nj} & \cdots & W_{NN} \end{bmatrix} \tag{19}$$

As we know, the sum of entries in each local weight vector is equal one. Consequently, bringing them to the supermatrix may make the sum of each column bigger than one. This means the supermatrix is unweighted and two factors from two different clusters were not compared rationally with respect to another particular factor. Saaty and Vargas (2013) suggest another matrix labeled cluster matrix in order to be multiplied in the supermatrix entries. The new matrix shows the normalized weights associated with clusters (not factors):

$$CC = \begin{bmatrix} C_{11} & \cdots & C_{1j} & \cdots & C_{1N} \\ \vdots & & \vdots & & \vdots \\ C_{k1} & \cdots & C_{kj} & \cdots & C_{kN} \\ \vdots & & \vdots & & \\ C_{N1} & \cdots & C_{Nj} & \cdots & C_{NN} \end{bmatrix} \tag{20}$$

where C_{kj} is the weight of cluster k respect to cluster j. After multiplying every single entries of W_{kj} in C_{kj}, the weighted supermatrix will be achieved. To reflect indirect effects of the factors on each other, the supermatrix raised to the infinite power in order to the convergence of weights take place. The resulted supermatrix is called the limit supermatrix (Saaty, 1990, 1996). Each column at the limit supermatrix consists of the global weights respect to corresponding factor which reveal whole direct and indirect relations between factors.

4. Proposed Framework

4.1. Network structure of the problem

Once project risks are identified, their response strategies need to be discovered. Meanwhile, a pool of potential actions is available and decision makers choose the best ones which maximize the utility function, subject to the constraints.

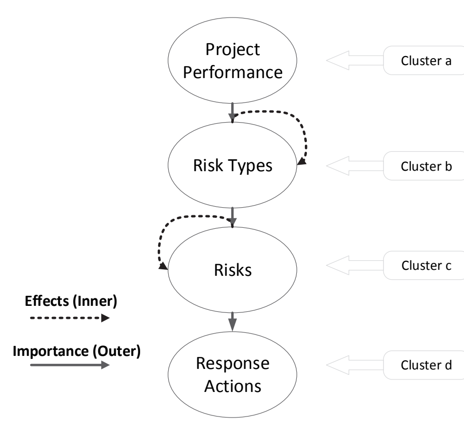

Fig. 1. Nonlinear network structure of the problem

Note that responses to a particular risk could decrease/increase the severity of the other risks, too. In addition, if actions do not be performed correctly against risks, meeting the desirable performance of the project would be problematic. Moreover, there are some interdependencies between risks which make the problem more complicated.

4.2. Mathematical Model Formulation

Obtained weights from ANP will be put in the following mathematical programming model:

$$\max\ f = \sum_{j\in J} v_j x_j \tag{21}$$

subject to

$$\sum_{j\in J} (ac_j + p_j^{"} c_j^{"}) x_j + \sum_{i\in I}\sum_{j\in J} p_{ij}^{'} c_{ij}^{'} x_j + \sum_{i\in I} p_i rc_i (1 - z_i) \le bud \tag{22}$$

$$\sum_{j\in J_i} x_j \le \mathbb{M} z_i \quad \forall i \in I \tag{23}$$

$$\sum_{j\in J_i} x_j \ge z_i \quad \forall i \in I \tag{24}$$

$$x_j \in \{0, 1\} \quad \forall j \in J \quad \text{and} \quad z_i \in \{0, 1\} \quad \forall i \in I \tag{25}$$

In the above model, I is the set of risks threatening the project, J is the set of corresponding response actions and J_i s are the sets of actions responding risk event i .Therefore, x_j is a binary decision variable which is equal to one, if action j is selected; otherwise, it is equal to zero. v_j is the value of action j which is obtained from the limit supermatrix in the previous section. p_i and rc_i are probability and cost of risk event i, respectively. The cost of implementing action j is denoted by ac_j . Also, $p_{ij}^{'}$ and $c_{ij}^{'}$ are the reduced probability and cost of risk i after implementing action j, respectively. $p_j^{"}$ and $c_j^{"}$ are probability and cost of secondary risks which consequently may happen after implementing action j. If risk i receives at least one response, then z_i as an auxiliary decision variable is equal to one; otherwise, it is equal to zero. $\mathbb{M}$ is a parameter that is chosen sufficiently large to simplify modelling. bud is the reserved budget, which provides support only for responding to risks. The suggested model is a zero-one integer programming that take into account a budget constraint.

4.3. Proposed process for risk evaluation and response planning

The decision-making framework consists of three main phases. In the first phase, all risks and responses are identified and the corresponding structure (linear or non-linear) is conducted. In the second phase, the relations between all elements are investigated and their global scores are adjusted. In the last phase, the capability of handling risks based upon resource budget is surveyed. The whole process is shown in Fig. 2.

If the responses do not satisfy managers, then the structure would be revised and solving the problem continues until the most appropriate responses be achieved.

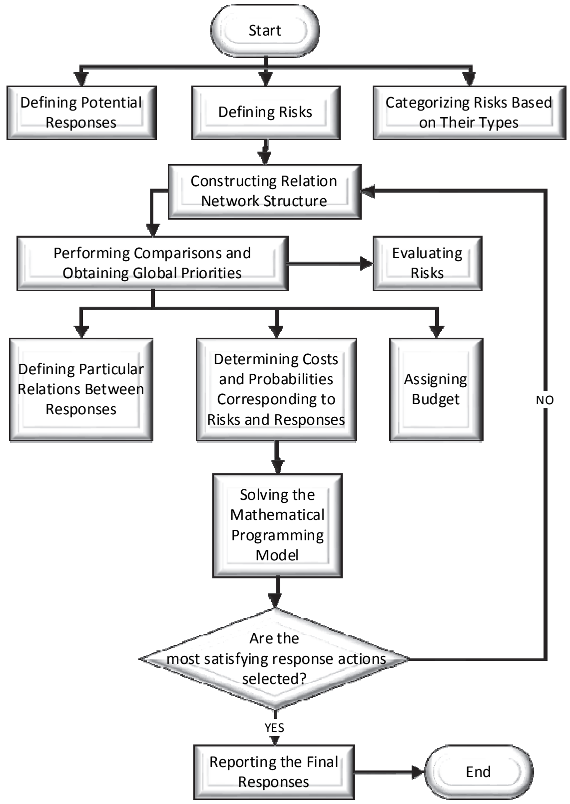

Fig. 2. The flow diagram of the proposed framework

5. An Empirical Study

Geothermal energy is the heat from the Earth. It's clean and green. To access the reservoir of geothermal energy, wells are drilled into underground. They often go down in the hundreds of meters. This is a complicated process, since it deals with breaking the ground and removing the rock extracts from it. Accessing adequate resource for exploitation is the final purpose of the geothermal drilling project. National Iranian Drilling Company (NIDC) and Renewable Energy and Energy Efficiency Organization (SATBA) are responsible for implementing geothermal drilling projects in Iran. A group of actors of these organizations was asked to set risks, responses and corresponding parameters for a particular drilling project in the northwest of Iran. The set of threatening risks is shown in Table 4.

Table 4
Set of risks for a geothermal drilling project (the third column refers to costs may caused by risk events)

Risk Name	Description	Estimated Cost	Probability
R1	Bureaucratic government system	300	0.7
R2	Collapsed casing	1250	0.3
R3	Delay in equipment delivery to the site	430	0.5
R4	Dissolved gas in formation water	730	0.4
R5	Drill string breakdown	920	0.2
R6	Equipment lost or stuck in hole	1070	0.15
R7	Extreme weather conditions	350	0.35
R8	High salinity in formation water	785	0.1
R9	Lost circulation	1340	0.1
R10	Non-productive well	1760	0.05
R11	Overpressure of the formation	1950	0.25
R12	Toxic gases (like H2S) released from well	835	0.1

Also, the most important associated responses are in Table 5. These response actions may cause other risks with particular impact and probability which are also show in Table 5:

Table 5
Set of risk response actions for a geothermal drilling project (the third column refers to implementation cost of actions)

Response Name	Description	Estimated Cost	Secondary Risk Cost	Secondary Risk Prob.
A1	Adding inhibitors	230	45	0.08
A2	Controlling injection pressure limit	170	0	0
A3	Creating protective coating on drillpipe	370	30	0.03
A4	Improving casing design	360	0	0
A5	Drilling a sidetrack	570	180	0.2
A6	Further exploration of field before the developments	240	0	0
A7	Hiring careful, experienced and skillful site labor	280	0	0
A8	Improving engineering of the wellhead systems	430	0	0
A9	Improving hole cleaning by chemicals	200	50	0.1
A10	Improving HSE conditions	160	0	0
A11	Keeping the bottomhole pressure low	220	25	0.15
A12	Making good relationship with government and NGOs	180	60	0.1
A13	Modifying construction procedures based on local weather	350	100	0.35
A14	Preparing a comprehensive training	190	0	0
A15	Providing rotary steerable systems	680	80	0.1
A16	Purchasing insurance or guarantee fund	320	0	0
A17	Tracking the orders more precisely	140	0	0
A18	Using a degasser	215	30	0.06
A19	Using water and chemicals to dissolve salts	250	20	0.04

As we discussed before, there is a network of relations involving risks, their responses, criteria, objectives and etc. The proposed network for our problem consists of four clusters. The first cluster is project performance, including one factor as the goal. Second cluster contains three distinct risk types, called technical risks, management risks and natural risks. Third cluster includes twelve risks described in Table 4. And finally, fourth cluster includes nineteen available responses to risks described in Table 5. Outer dependence (dependency between factors of two clusters) and inner dependence (interdependency between elements of a cluster) are shown in Fig.3, Fig.4, Fig.5 and Fig.6.

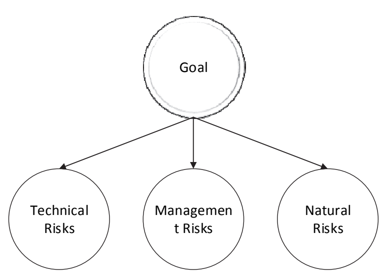

Fig. 3. Relations of risk types with respect to goal (cluster b respect to cluster a)

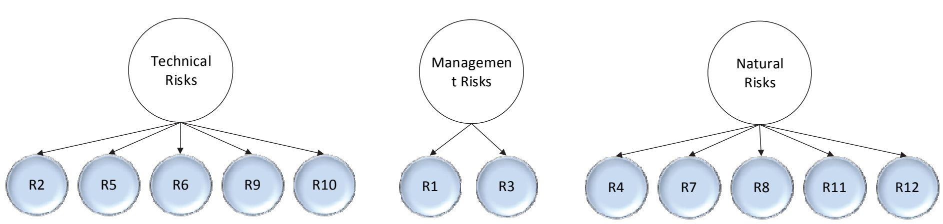

Fig. 4. Relations of risks with respect to risk types (cluster c respect to cluster b)

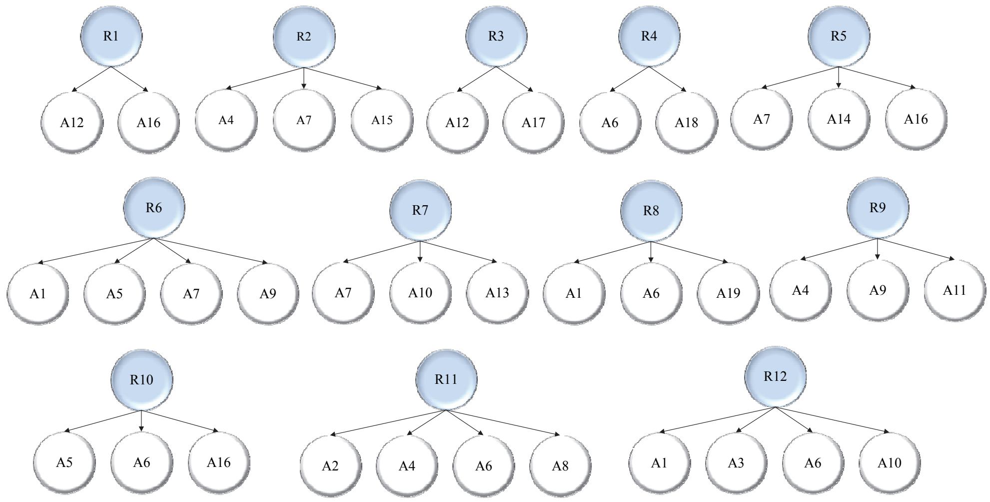

Fig. 5. Relations of response actions with respect to risks (cluster d respect to cluster c)

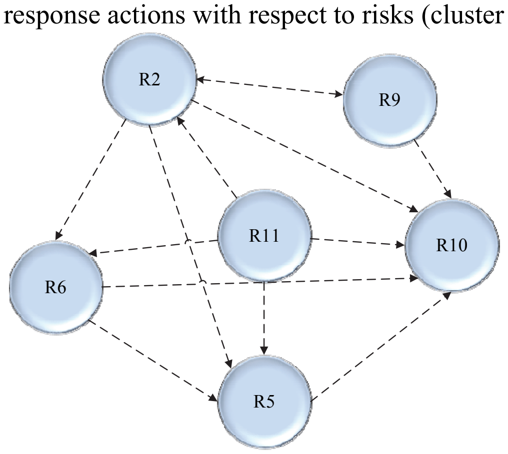

Fig. 6. Effects of risks on each other (cluster c respect to itself)

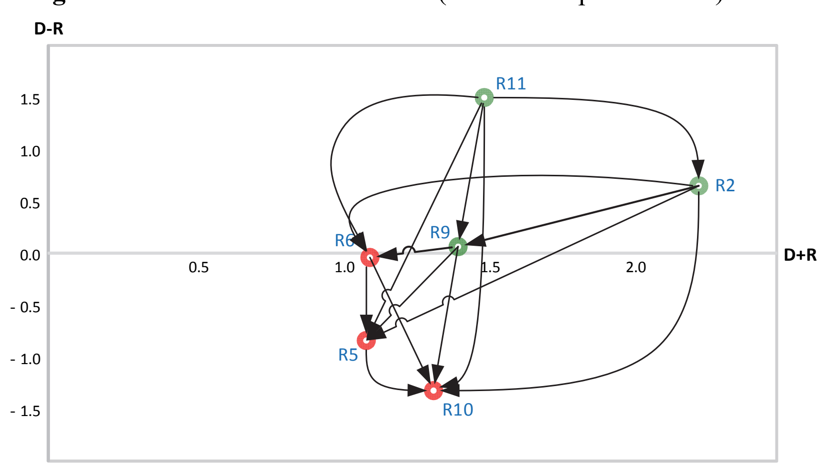

Fig. 7. The impact-diagraph-map of total relation for risks

Clearly, all four categories of responses are held in above relations. For instance, to handle R5 (drill string breakdown), A16 (purchasing insurance or guarantee fund) seeks transference strategy and A7 (hiring careful, experienced and skillful site labor) seeks mitigation strategy. Further, to respond to R7 (extreme weather conditions), A13 (modifying construction procedures based on local weather conditions) is an avoidance strategy. If none of the responses are selected, then the acceptance strategy is applied automatically.

After collecting comparisons, testing consistency, and capturing inner dependent relations; the local weights are calculated. The inner dependencies between risks are shown in Fig. 6. With regard to (15) and (16), $D_i + R_j$ represent the strength of influences given and received. On the other hand, $D_i - R_j$ is another advantageous indicator. If $D_i - R_j$ is positive, then factor i is affecting other factors (cause), and if $D_i - R_j$ is negative, then factor i is being influenced by other factors (effect) (Yang et al. 2008).

Based on these assumptions, the impact-diagraph-map of total relation for some risks (cluster c) is illustrated in Fig.7.

As can be seen from Fig.7, R11 is a risk with most influence on others. By contrast, R10 receives most influence from others. Meanwhile, SuperDecision software computes global weights and represents them within the limit supermatrix (Appendix). Global weights of risks are shown in Table 6.

Table 6
Global weights of risks

Risk Name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
Global Weight	0.033	0.073	0.008	0.012	0.011	0.017	0.006	0.009	0.054	0.020	0.085	0.009

The higher weights of R2 and R11 reveal their importance. Impact-diagraph-map and global weight tool, both evaluated R11 as the most threatening risk. These tools complement each other in order to present a novel method for risk evaluation.

Now, using captured global weights of actions, we run the zero-one mathematical model. Suggesting by actors, three more constraints are added to the model:

$$x_8 \leq 1 - x_{18} \tag{26}$$

$$x_7 \leq 1 - x_{17} \tag{27}$$

$$x_7 \leq 1 - x_{14} \tag{28}$$

These constraints show the interdependencies between response actions. According to (26), if A8 is performed, there is no need to perform A18. Two next constraints are based on the same rationale. The model, with objective function (21) and system of constraints (28)-(28) is coded in GAMS software, using CPLEX as MIP solver. Considering 3200 units budget which is reserved as a part of project cost, the model is implemented. After running, among nineteen response actions, eight response actions are selected: A2, A4, A6, A7, A11, A12, A16, A18. Also, the optimal objective function is equal to 0.340. In spite of neglecting eleven actions, the eight chosen responses are against all of the risks and decrease their impact or probability impressively.

Note that the reserved budget may not be adequate. Thus, we analyze changing budget (in low amount) in order to observe how objective function changes.

Fig.8 shows how budget reduction can lessen utility function. In low budget, the severity becomes worse as all the risks are not possible to be responded (red dashed line) and it makes a dangerous situation. Because managers are forced to adopt acceptance strategy.

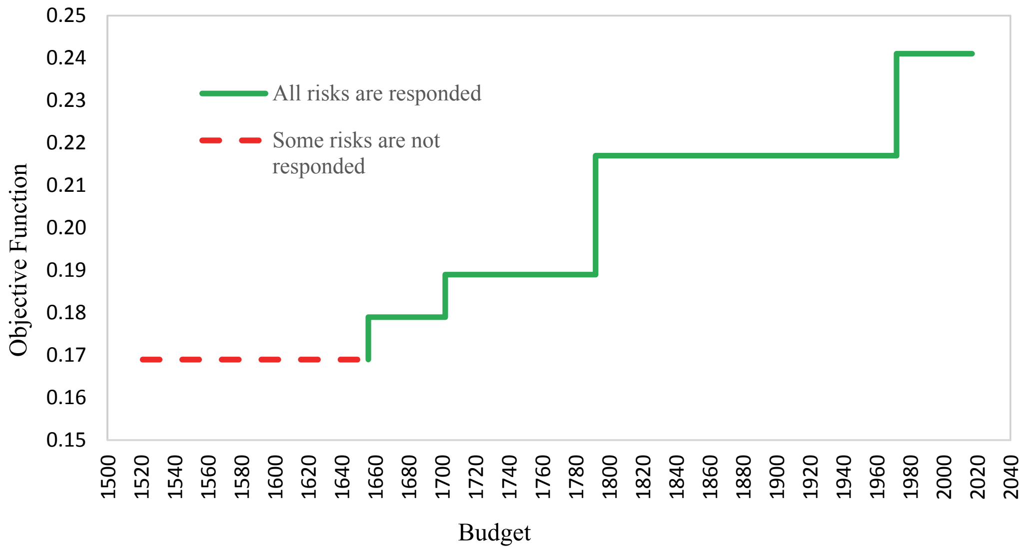

Fig. 8. The effect of changing reserved budget on objective function

6. Conclusion

Risk response selection is an extensively concerned. In this study, an integrated novel method was developed through incorporating ANP, DEMATEL, zero-one programming and fuzzy theory. Such an integrated approach is helpful for evaluating risk and planning their responses in a geothermal drilling project. In this method, we drew a network of factors that express the relation between project goal, different types of risks, distinct risks and corresponding responses. The weights of the factors were reflected by FANP and DEMATEL tools. Due to restriction on reserved budget, the resulted weights were utilized in a zero-one integer programming model. Then, the optimal response strategies were detected. Moreover, the major risks were analyzed by an impact-diagram-map.

The main contributions of the proposed method can be summarized as follows:

- Presenting a network of factors, including risks and responses with their inner relations and outer relation on each other.
- Considering all categories of risk responses (avoidance, mitigation, acceptance and transference) within the set of responses.
- Considering impacts and probabilities of secondary risks, caused by responses.
- Introducing a novel method for risk evaluation and response planning in a geothermal drilling project.

There are some potential future works. The inherent uncertainty in parameters, especially costs could be handled by monte-carlo simulation method. On the hand, for conducting the limit supermatrix, group decision-making could be more helpful. Furthermore, we suggest other case studies such as oil project and software project to emphasize on the strength of the proposed model.

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Appendix. Supermatrices

Table A1
The weighted supermatrix

	Goal	TR*	MR*	NR*	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19
Goal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TR	0.499	0.125	0.214	0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MR	0.163	0.188	0.071	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NR	0.338	0.188	0.214	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R1	0.000	0.000	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R2	0.000	0.106	0.000	0.000	0.000	0.065	0.000	0.000	0.179	0.241	0.000	0.000	0.308	0.114	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R3	0.000	0.000	0.101	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R4	0.000	0.000	0.000	0.115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R5	0.000	0.066	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R6	0.000	0.074	0.000	0.000	0.000	0.000	0.000	0.000	0.130	0.000	0.000	0.000	0.000	0.106	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R7	0.000	0.000	0.000	0.055	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R8	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R9	0.000	0.106	0.000	0.000	0.000	0.174	0.000	0.000	0.045	0.060	0.000	0.000	0.077	0.076	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R10	0.000	0.149	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R11	0.000	0.000	0.000	0.171	0.000	0.261	0.000	0.000	0.148	0.199	0.000	0.000	0.116	0.156	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R12	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.089	0.000	0.407	0.000	0.000	0.000	0.146	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.284	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.296	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A4	0.000	0.000	0.000	0.000	0.000	0.116	0.000	0.000	0.000	0.000	0.000	0.000	0.140	0.000	0.147	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.131	0.000	0.000	0.000	0.093	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.201	0.000	0.000	0.000	0.186	0.000	0.204	0.347	0.146	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A7	0.000	0.000	0.000	0.000	0.000	0.116	0.000	0.000	0.220	0.191	0.177	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.089	0.000	0.000	0.140	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.260	0.000	0.000	0.000	0.000	0.412	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.220	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A12	0.000	0.000	0.000	0.000	0.842	0.000	0.263	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.563	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.140	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A15	0.000	0.000	0.000	0.000	0.000	0.267	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A16	0.000	0.000	0.000	0.000	0.158	0.000	0.000	0.000	0.140	0.000	0.000	0.000	0.000	0.204	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A17	0.000	0.000	0.000	0.000	0.000	0.000	0.737	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.799	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.407	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

* TR: Technical Risks, MR: Management Risks, NR: Natural Risks

Table A2
The limit supermatrix

	Goal	TR	MR	NR	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19
Goal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TR	0.067	0.067	0.067	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MR	0.042	0.042	0.042	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NR	0.054	0.054	0.054	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R1	0.033	0.033	0.033	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R2	0.073	0.073	0.073	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R3	0.008	0.008	0.008	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R4	0.012	0.012	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R5	0.011	0.011	0.011	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R6	0.017	0.017	0.017	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R7	0.006	0.006	0.006	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R8	0.009	0.009	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R9	0.054	0.054	0.054	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R10	0.020	0.020	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R11	0.085	0.085	0.085	0.085	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R12	0.009	0.009	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A1	0.013	0.013	0.013	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A2	0.048	0.048	0.048	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A3	0.005	0.005	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A4	0.057	0.057	0.057	0.057	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A5	0.008	0.008	0.008	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A6	0.078	0.078	0.078	0.078	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A7	0.030	0.030	0.030	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A8	0.038	0.038	0.038	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A9	0.018	0.018	0.018	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A10	0.010	0.010	0.010	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A11	0.024	0.024	0.024	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A12	0.061	0.061	0.061	0.061	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A13	0.007	0.007	0.007	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A14	0.003	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A15	0.039	0.039	0.039	0.039	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A16	0.022	0.022	0.022	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A17	0.012	0.012	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A18	0.020	0.020	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A19	0.007	0.007	0.007	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000