J. Appl. Res. Ind. Eng. Vol. 5, No. 1 (2018) 81–96

Journal of Applied Research on Industrial Engineering
www.journal-aprie.com

Prioritization of Different Solvency Monitoring Systems of Iran Insurance Company Using Combined Approach of Analytic Network Process and DEMATEL

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PAPER INFO

Chronicle:
Received: 07 September 2017
Accepted: 08 January 2018

Keywords:
Different Solvency Monitoring Systems.
Iran Insurance Company.
Analytic Network Process (ANP).
DEMATEL.

ABSTRACT

The Bankruptcy of insurance companies compared to companies in other industries can have a more devastating impact on the customers of this industry and on society as a whole; because the insurance company's bankruptcy is equal to the risk of the economic presence of the insurer and third parties. Severe outcomes of insurance company's bankruptcy have made financial monitoring institutions to design systems for evaluation and supervision of insurance companies' solvency in order to reduce bankruptcy risk of these companies. Inappropriate design of these systems may transmit incorrect signals to the insurance companies, lawmakers, and insurers and would have irreversible effects. Thus, the current research aims at prioritizing different solvency monitoring systems of Iran Insurance Company using Analytic Network Process (ANP). This is an applied research in terms of purpose, and it is descriptive - analytical research in terms of data collection method. The identified indexes for evaluation and monitoring the insurance companies' solvency include the quantitative computational aspects, flexibility, and qualitative aspects. Following data collection using the network analysis software, which was used for advanced hierarchy analysis and DEMATEL, which was used for ranking qualitative, quantitative aspects, and flexibility, it is concluded that the quantitative computational index has the highest impact, and the qualitative index has the lowest impact on the solvency of Iran Insurance Company.

1. Introduction

Environmental changes have caused significant changes in the structure of organizations; so the traditional and mechanic structures are no longer suitable to meet environmental changes, and many old great organizations destroyed due to inability to match with the environment. The structures get easily outdated and old in highly dynamic environments today because of increased international operations of the organizations [1].

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DOI: 10.22105/jarie.2018.128535.1036

Insurance market is one of the most successful markets in Europe, USA, South Eastern countries, and even India; the millions of the jobs are dependent on the insurance industry in the world [2]. Thus, the insurers in these countries pay any kind of damage resulting from the accidents with respect to the affected people and even ignore the possibility of a misdiagnosis of the claim at most of the times; so that avoid any possible hardship that distracts the customers. In our country, even though the insurance industry has a very long history, the released statistics by the Sigma Institute indicate that the insurance industry in Iran is lagging behind compared to other countries in the world [3]. It is important to take an effective step in improving the insurance industry for developing the countries [4]. The bankruptcy of insurance companies compared to companies in other industries can have a more devastating impact on the customers of this industry and on society as a whole, because the insurance company's bankruptcy is equal to the risk of the economic presence of the insurer and third parties. Severe outcomes of insurance company's bankruptcy have made financial monitoring institutions to design systems for evaluation and supervision of insurance companies' solvency in order to reduce bankruptcy risk of these companies. Inappropriate design of these systems may transmit incorrect signals to the insurance companies, lawmakers, and insurers; would have irreversible effects.

The current method of monitoring insurance companies (tariff regulation) is not compatible with the prevailing area of the country's insurance industry, where liberalization and deregulation are its main components. The margin of financial empowerment is a tool used in many countries in the field of financial supervision of insurance companies. In this method, instead of direct supervision of the margin of financial empowerment of insurance companies, which represents their financial ability to meet their commitments, are evaluated [5]. For this purpose, a framework is needed for evaluating systems designed for monitoring solvency of insurance companies. For the first time, the authors of [23] provided a framework for the critical evaluation of risk-based systems. The KPMG Institute has also developed a framework for analyzing different methodologies; it designed to assess the financial position of insurance companies. Gatzert, Holzmüller and Schmeiser [24] adjusted the framework proposed by Cummins and added four new criteria to it arguing that regulations related to monitoring solvency have highly changed in the recent years and considered trends in the integration of financial markets. In this article, they develop such an internal risk management approach for property-liability insurers that is based on the Dynamic Financial Analysis (DFA). The proposed concept uses a simulation technique; models the central risk factors from the investment and underwriting areas of an insurance company. On the basis of the data that has been provided by a German insurer, the ruin probabilities under different scenarios and varying planning horizons are calculated [6].

The evaluation systems have a vital role in evaluating and improving quality services by certain criteria. The significance of the study in the way of this research can be allowed by insurance companies to take a decision or formulate a policy that controls, monitors and improves service quality in the future [7]. The choice of each mode in the mentioned dimensions has advantages and disadvantages; therefore, in general, one cannot easily assess which of the factors is better [8]. Thus, this research attempts to answer this question: how is prioritization of different solvency monitoring systems of Iran Insurance Company using combination of ANP[1] and DEMETEL[2]?

The Decision Making Trial and Evaluation Laboratory (DEMATEL) and the Analytical Network Process (ANP) methods allow the modeling of the problems in an evaluation system. They also excel

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[1] analytic network process
[2] Decision Making Trial and Evaluation Laboratory

at measuring the interdependencies among the criteria in a hierarchy or network. The DEMATEL and ANP methods in an evaluation system enable various trouble shooting, such as supplier performance, learning materials, information security risks, company performance, etc. The ANP grading presents the interdependencies between the criteria and sub-criteria, giving a more general framework for decision-making without assuming independence among the elements. The ANP method, on the other hand, is unable to identify interdependencies among individual criteria for doing this requires in-depth discussion and expert opinions. The ANP method needs an additional tool to present such interdependencies among the criteria such as the DEMATEL method. Additionally, the DEMATEL method makes clear the interactions in a decision model, grades the weights of criteria, supports ANP decision-making, and finds and analyzes the dominant criterion in a system. The implementation of DEMATEL and ANP aims at improving decision-making processes by taking into account interdependencies among the criteria [7], that combination of methods will be used in order to evaluate insurance companies.

2. Theoretical Literature

Insurance industry has faced many challenges including pressures resulting from foreigner companies such as terrorist attacks in recent years and the changes governing structure of the companies. Due to the high payments have been made by insurance companies for these types of losses, other insurance companies do not have the ability to calculate the risk of these types of hazards; most importantly, they tend not to accept the relevant risks. On the other hand, significant opportunities in capital markets have forced insurance companies to adopt new business models. Customers are also affected by these changes and their taste is also constantly changing. Eventually, processes are automated, the products are standardized. Consequently, the pressures to reduce total costs get more and more [9]. In general, these changes are due to the following factors: Globalization, newcomers, and emerging companies, variable and low-stability economic environments, de-regularization and imposing new regulations, changes in demographic characteristics and old age, sociocultural changes, and major changes in technologies and the way of performing transactions at the macro level. Major factors affecting the lack of growth and development of the insurance industry in Iran can be classified into four categories:

1. Inappropriate service delivery (lack of appropriate service delivery).
2. Low income level in the country.
3. Lack of general acceptance of insurance culture at national level.
4. Inefficient management of resources in insurance companies of the country [10].

Meanwhile, first and fourth factors directly result from inefficiency and poor performance of insurance companies, and the third factor actually has indirectly the same root, because of the insurance companies have efficient and strong performance, satisfied customers act as a factor for promoting and developing insurance culture in the country [2]; thus, the effective steps can take for qualitative and quantitative improvement of services have been delivered to customers attracting them and effective management of these companies by applying effective strategies especially in information system development sector.

Prosperity system models can be classified into two classes as direct solvency models and indirect solvency models [11]. In the spectrum of indirect models, a range of general and prescriptive ethical guidelines has been presented in New Zealand. The advanced dynamical models based on cash flow simulations in countries such as Switzerland and Sweden can be found. For direct models, specific models are based on financial ratios to monitor the solvency of insurance companies. The examples of such models include IRIS, FAST, HHM and EWIS model [12]. Although all solvency evaluation models and systems ultimately provide the minimum cost, their methodologies to achieve this stage is different. As observed in Table 1, there is a distinction between factor models, dynamic models, and combined models in this framework and each of them has their own sub-categories.

Table 1. Overall framework for indirect models to assess the empowerment [11].

Introduced		**Model Sample**	**System Types**	
Date	**By**			
2001	New Zealand	New Zealand Insurance Law	No Model	
2004	Europe Union	Prosperity	Non risk-based (fixed ratio)	
1973	Australia	Australia Insurance Law		
2001	Australia	General insurance modification law		Static factor systems
1994	USA	Risk-based capital	Risk-based	
1996	Japan	Prosperity margin standard		
1994	NAIC (USA)	FAST		
2002	Germany	Stress Testing		
2006	Netherlands	Financial evaluation framework	Scenario-based	Dynamic systems based on cash flow
1999	Cummins and Griss	Cash flow simulation model	Principle-base	
2004	Schmeiser	Cash flow based model		
2004	England	Proprietary capital assessment	Combined systems	
2006	Swiss	Swiss solvency test		
2011	Swiss	Market solvency test	Scenario-based	Dynamic systems based on cash flow
2017	USA	Cyber insurance solvency	Combined systems	
2017	Sweden	Cyber insurance solvency		
2017	Germany	Insurance market power	Risk-based	Static factor systems
2017	Europe Union	Insurance demand severity	Regression model	
2018	Fung et al	China Solvency System	Risk-based	

According to this classification, the first group of systems does not necessitate any specific level of the capital, thus, there is no model for solvency assessment. An example of such a system can be observed in New Zealand, which only insurers are asked to match to the insurance fair code. According to this code, the insurer should act ethically, pursue fair value accounting standards, and publish annually the ranks, which are taken from reputed and international institutes such as A. M. Best, S & P, and FICH scales. The second group of models utilizes static factor methodologies and are classified into two groups: simple factor (fixed ratio and non-risk-based and risk-based factor). EU solvency system or pre 2001 system in Australia are examples of simple factor system [12]. USA risk-based capital standards that were developed in 1994 referred to as the most famous example of risk-based factor systems. However, the third group of models is required to use dynamic systems based on cash flow, which is classified into two classes. The first class, i.e. scenario models, analyzes impacts of the worst possible scenario (such as shock in stock exchange or payment for natural disasters) on the solvency of insurance companies. The simplest example of such system is stress testing, which was developed by Germany supervisory organization in 2002. The second class of models, which is known as principle-centered cash flow-based models, adopts a more general approach. In this approach, some assumptions about the future economic situation and insurer reactions to them are utilized in order to stimulate probable financial status over the time.

The fourth group, i.e. combined models, is a combination of scenario-centered cash flow-based models and risk-based factor systems or principle-centered models. Example of such combined systems can be observed in Swiss known as Swiss solvency test. In addition, the solvency project is being currently implemented in EU is also among the combined model group [11]. The national association of insurance agents developed a risk-based monitoring system called risk-based capital for life and health insurers, and it extended for public insurers (non-life insurance) in 1993. Four risk groups are identified in this model and are used in it: Asset risk, credit risk, insurance risk, and business risk. These four risk groups are common in both life and non-life insurances. However, additional risks can be considered in each insurance branch, in addition to these four risk groups [6]. It should be noted that RBC formula in this system is designed in such a way that can impose a minimum legal level of risk-based capital, and this system aims at accounting all risks, which are imposed on the insurance company, whether from the asset or from balance sheet debt [11]. There are five results for RBC calculations that allowed control level specified through comparison of total adjusted capital with Risk-Based Capital (RBC). The necessary level of risk-based capital is annually calculated. There are corrective measures depending on the reported risk-based capital level, which are applied if necessary [12].

2.1 Swiss Solvency Test

This system is a supervisory tool of lawmaker body in Swiss for improving the process of identifying risks that encounter by an insurance company. In fact, this system includes a random modeling and scenario making process for market risk, insurance risk, and credit risk. Computational elements of this system include a criterion known as capital under risk and a criterion known as target capital. The first criterion means economic capital level available, and the second one measures the risk. The time perspective has been considered for this system is one year [6].

2.2 EU Solvency System

Solvency system was approved in 2011 in the European parliament and it has been implemented since 2012. This system aims at ensuring the financial health of insurance companies at the worst conditions in order to support insurers and financial markets as well as formation of unit insurance market with identical regulations. The main feature of solvency is that it considers all different types of risk and takes into account both balance sheet debt and assets [12].

The main features of the Solvency Guideline are considering two levels of capital requirements, namely the minimum capital requirement and the requirement for wealth solvency. There are three pillars for the system to calculations of: The permissibility of using internal models by insurance companies, the greatest possible compatibility between financial sector with insurance, and ultimately similar to Basel II system for banking supervision, there are three pillars for the system. These three pillars are quantitative requirements, qualitative requirements and market order [11].

The authors [13] investigate how regulatory changes influence the role of risk management in insurance companies, more specifically the impact which Pillar II of Solvency Assessment and Management (SAM) may have on risk management in a South African insurance company. They showed that the priority criteria for action were leadership, quality of service, service strategy, and organizational structure. Oskooii and Albonaiemi [14] identified 39 damages in central insurance, the main of which are as follows: Mismatch between individual and organizational interests, lack of definition for service quality in the view of customers, lack of promotion of love and interest to the customer in the organization, lack of mutual relationship between processes, etc. Rejda [12] studied the perception of managers of service sector about the future of customer services. This research suggested that those service organizations which focus on the roles and capabilities of the customer service staff in meeting customer needs and supporting them through active service leadership would be successful in the future. The work [15] entitled 'The Baldrige education criteria for performance excellence framework' tested causal relationships in educational performance excellence and Baldrige award experimentally. Their findings indicated that the leadership is the drive for all elements of Baldrige system, namely measurement, analysis and management of knowledge, strategic planning, focus on faculty and student and focus on the market [16].

Fung et al. [17] identified the main features of the China Risk-Oriented Solvency System (C-ROSS) and compared its rules and standards with those of the Risk-Based Capital (RBC) system in the United States, the Solvency II system in the European Union, and the Swiss Solvency Test (SST) in Switzerland. They analyzed C-ROSS according to 11 criteria and found that the system scores are substantially better than those of RBC and more or less as good as those of the Solvency II or SST systems.

3. Methodology

This is an applied research in terms of purpose, and it is descriptive - analytical research in terms of data collection method. Research statistical population included staff of Iran Insurance Co. with the minimum educational degree of Ph.D. and 15 years of working experience (n = 45). Since research and statistical population are limited, the census is used, and the whole population are sampled. The following is the review of literature and identification of factors in pairwise matrices (pairwise matrices are questionnaires specific for comparative methods such as analytic network process); the questionnaires are provided and are given to the statistical population. The validity of a questionnaire is measured using expert ideas, and the reliability is measured by inconsistency rate. The inconsistency rate was 0.0033 and since this value is less than 0.1, the questionnaire is reliable. Table 2 shows the indexes and options identified from the reviewed literature. After collecting the data, the indexes are evaluated and are weighed using the network analysis software, and the model and problem configuration are made and are ranked using DEMATEL software.

Table 2. Indices monitoring the empowerment [11].

Index	Alternative
Computational quantitative aspects	Risk sensitivity
	Computational formula calibration
	Focus on market (economic) value
	Simplicity of computational formula
Flexibility	Flexibility over time
	Focus on highest bankruptcy cost
	Taking systematic risk and financial crises into account
Qualitative aspects	Providing appropriate incentives
	Avoiding inappropriate reporting
	Taking management risk into account
	Strengthening insurer risk management and market regulation

3.1 Analytic Network process (ANP)

The analytic network process can be used for decision-making problems that are more complicated than the analytic hierarchy process. Analytic network process is composed of two parts: The first part is a network of criteria and sub-criteria that constitutes trading within the studied system, and the second part is a network of interactions between elements and clusters. A cluster is a set of related elements within a network or subnet. All interactions and feedback within the clusters called 'internal dependency', and interactions and feedback between clusters called 'external dependency.' The inner and outer dependency is the best tool that decision-makers can take and consider influence and interactions between clusters and elements in relation to a particular element. In this case, a pairwise comparison involves all combinations of element/cluster relationships in a systematic manner. The analytic network process uses the same scales (9-1) as the analytic hierarchy process. The combined results are obtained after implementing all pairwise comparisons and finally combined results are combined so that the result is achieved, which is a set of priorities [18]. The current research aims at using multi-index decision-making model and decision-makers will be able to obtain their preferences regarding indexes as numerical weights.

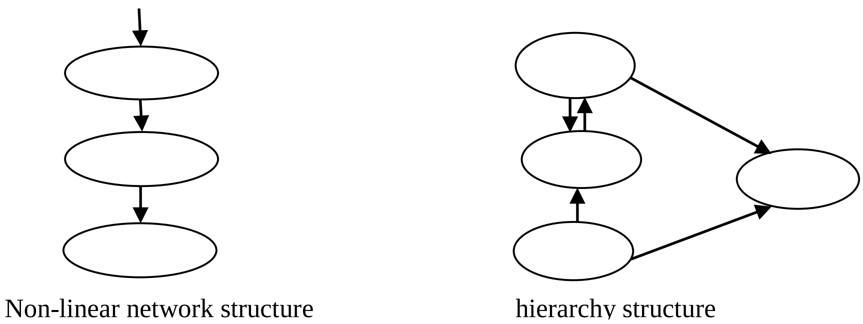

Fig. 1. The difference between hierarchy structure (linear) and network structure (non-linear).

In ANP method, first, the network structure is formed. Criteria/sub-criteria and alternatives are defined, then the cluster of elements are determined. The network is formed by basing on the relationship between clusters and within elements in each cluster. Then the pair-wise comparison matrices are formed and the priority vector is obtained. Decision-makers use 1–9 scale while making the pair-wise comparisons. This scale can be seen in Table 3 [18].

Table 3. Saaty's 1–9 scale.

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values

This pair-wise comparison yields an n × n matrix A as follows:

$$A = \left[a_{ij}\right] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

In matrix A, the problem becomes one of assigning to the n criteria *C1, C2, …, Cn* and a set of numerical weights *w1, w2, …, wn* that reflect the recorded judgments. If *A* is a consistency matrix, the relations between weights *wi* and judgments *aij* are simply given *by wi/wj = aij (for i, j = 1, 2, …, n)*.

$$G = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{pmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n \end{pmatrix} \end{array} \tag{2}$$

After that, the unweighted super matrix is formed as is seen in Eq. (3).

$$W = \begin{array}{cc} & \begin{array}{cccc} C_1 & C_1 & C_1 & C_1 \\ e_{11}e_{12}..e_{1m1} & e_{11}e_{12}..e_{1m1} & e_{11}e_{12}..e_{1m1} & e_{11}e_{12}..e_{1m1} \end{array} \\ \begin{array}{cc} C_1 & e_{11} \\ . & e_{12} \\ . & . \\ . & e_{1m1} \\ . & e_{21} \\ C_2 & e_{22} \\ . & . \\ . & e_{2m2} \\ . & . \\ C_n & e_{n1} \\ & e_{n2} \\ & . \\ & e_{nmn} \end{array} & \begin{pmatrix} W_{11} & W_{12} & \cdots & W_{1n} \\ & & & \\ & & & \\ & & & \\ & & & \\ W_{21} & W_{22} & \cdots & W_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ & & & \\ W_{n1} & W_{n2} & \cdots & W_{nn} \\ & & & \\ & & & \end{pmatrix} \end{array} \tag{3}$$

Where *Cn* refers to n^th^ set, e_{nm} refers to m^th^ criterion in n^th^ set, and *Wij* refers to eigenvector of criteria impact in j^th^ set compared to i^th^ set. In addition, if j^th^ set has no impact on i^th^ set, thus *Wij*= [0].

The unweighted super matrix's columns contain the priorities derived from the pair-wise comparisons of the elements. In an unweighted super matrix, its columns may not be column stochastic. To obtain a stochastic matrix, i.e. each column sums to 1, the blocks of the unweighted super matrix should be multiplied by the corresponding cluster priority [19]. Step 4: After the weighted super matrix is obtained, it can be raised to limiting powers to calculate the overall priority weights. The best alternative is selected according to this limit matrix. The importance weights of alternatives and criteria are determined and the highest importance weight shows the best alternative [20].

3.2 DEMATEL Method

The DEMATEL method delineates the relations between various perspectives and helps the understanding of complex performance-related problems. It is the relation among the criteria acquired by the DEMATEL method that will be used to grade each criterion. The DEMATEL method is originated from the Geneva Research Centre of the Battelle Memorial Institute [25]. It is practical and useful for visualizing the structure of complicated causal relationships with matrices or digraphs. The matrices or digraphs portray a contextual relation between the elements of the system, in which a numeral represents the strength of influence. Hence, the DEMATEL method can convert the relationship between the causes and effects of criteria into an intelligible structural model of the system [19]. The essentials of DEMATEL method suppose that a system contains a set of criteria (*C1, C2, …,* *Cn*) and the particular pair-wise relations are determined for modeling with respect to a mathematical relation. The solving steps are as follows [19]:

The direct relation matrix (Z) is generated. The pair-wise comparison scale that decision-makers use and for the evaluating the criteria may be designated as five levels as has been shown in Table 4. The direct relation matrix is constructed by basing on the degrees of relative impacts derived from the pair-wise comparisons. In Eq. (4), the direct relation matrix Z is shown. In this matrix, *zij* denotes the degree of impacts of criterion *i* on the *j* criterion. Accordingly, all main diagonal elements *zij* of matrix Z are set to be zero [20].

Table 4. Pair-wise comparison scale.

Score	Definition
0	No influence
1	Low influence
2	Medium influence
3	High influence
4	Very high influence

$$z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{nn} \end{bmatrix} \tag{4}$$

The direct relation matrix Z is normalized through Eq. (5) and the normalized direct relation matrix X is obtained.

$$X = sZ, \qquad s = \min\left[\frac{1}{\max_i \sum_{j=1}^{n} |z_{ij}|}, \frac{1}{\max_j \sum_{i=1}^{n} |z_{ij}|}\right] \qquad i, j = 1, 2, \ldots, n \tag{5}$$

After the normalized direct relation matrix X is obtained, the total relation matrix T can be acquired by using Eq. (6).

$$T = X(1 - X)^{-1} \tag{6}$$

The threshold value is determined and the network relation map is obtained. Decision-makers must set a threshold value to filter out some significant influences in matrix T. Only the criteria whose effect in the matrix T is greater than threshold value must be chosen and is shown in a Network Relation Map (NRM). After setting a threshold value, let t_{ij} be the elements of the total relation matrix *T* like in Eq. (7), then the sum of rows and columns denoted by *Di* and *Ri* can be obtained through Eq. (8) and (9), respectively.

$$T = [t_{ij}]_{n*n} \quad i, j = 1, 2, \ldots, n \tag{7}$$

$$D_i = \left[\sum_{i=1}^{n} t_{ij}\right]_{n*1} = [t_i]_{n*1} \tag{8}$$

$$R = \left[\sum_{j=1}^{n} t_{ij}\right]_{1*n} = [t_j]_{1*n} \tag{9}$$

For instance, *D1* indicates the sum of direct and indirect impacts of the first criterion over other criteria. *R1* indicates the sum of direct and indirect impacts that the first criterion receives from other criteria. Then, *Di* + *Ri* and *Di* − *Ri* values are calculated for all criteria. *Di* + *Ri* represents the strength of relationships between criteria and $Di - Ri$ represents the strength of influences among criteria. If $Di - Ri$ has a negative value, then the criterion is in effect group and is called net receiver. If $Di - Ri$ has a positive value, then the criterion is in cause group and is called net causer. The network relation map can be acquired by mapping the ordered pairs of $Di + Ri$ and $Di - Ri$. Hence, the complicated causal relationships between criteria can be visualized into a visible structural model by the impact-digraph-map, which is also able to provide valuable insight for problem solving [22].

3.3 Combined Method

Step 1: Compare the criteria in the whole system to form super-matrix. The main super-matrix of special column vectors can be obtained from the pairwise comparison of criteria matrices. The relative significance value can be determined using the scales 1-9, which indicates the identical significance to high significance. The overall shape of this super matrix can be described as Eq. (3).

Step 2: Obtain the super-matrix via multiplication of normalized matrix, which is extracted according to Network Relationship Map (NRM) based on the DEMATEL method. The normalization has been used to extract the balanced super-matrix using the converting sum of each column to the unit (1). In traditional normalization, each criterion in one column is divided by the number of sets so that the sum of each column is exactly equal to the unit. This method denotes the fact that the set has identical weight. However, it is known that the impact of each set on the other sets may be different. Thus, the assumption of identical weight for each set to obtain the balanced super-matrix is not logical. This study uses NRM based on the DEMATEL method for solving this problem. First, DEMATEL method was used to extract NRM. Then matrix of sum effects of T and threshold value was utilized for developing a new matrix. If the value of sets is smaller than the threshold α, their value in matrix T is considered as zero, which means if their value is smaller than α, this value is obtained by decision-makers and has a lower impact on other sets. This matrix with alpha cutting is known as alpha cutting effect set, as is shown in Eq. (10).

$$NRM = T_\alpha = \begin{bmatrix} t_{11}^\alpha & \cdots & t_{1j}^\alpha & \cdots & t_{1n}^\alpha \\ \vdots & & \vdots & & \vdots \\ t_{i1}^\alpha & \cdots & t_{ij}^\alpha & \cdots & t_{in}^\alpha \\ \vdots & & \vdots & & \vdots \\ t_{n1}^\alpha & \cdots & t_{nj}^\alpha & \cdots & t_{nn}^\alpha \end{bmatrix} \rightarrow d_i = \sum_{j=1}^{n} t_{1j}^\alpha \tag{10}$$

If *tij*<α, then $t_{ij\alpha}=0$, otherwise, $t_{ij\alpha}=t_{ij}$ and t_{ij} is present in *T* effect sum matrix. It is needed that the alpha cutting effect matrix must be normalized by division by following formula. Thus, it is possible to normalized alpha cutting effect matrix and show it by *Ts*.

$$T_s = \begin{bmatrix} t_{11}^\alpha/d_1 & \cdots & t_{1j}^\alpha/d_1 & \cdots & t_{1n}^\alpha/d_1 \\ \vdots & & \vdots & & \vdots \\ t_{i1}^\alpha/d_i & \cdots & t_{ij}^\alpha/d_i & \cdots & t_{ij}^\alpha/d_i \\ \vdots & & \vdots & & \vdots \\ t_{n1}^\alpha/d_n & \cdots & t_{nj}^\alpha/d_n & \cdots & t_{nn}^\alpha/d_n \end{bmatrix} = \begin{bmatrix} t_{11}^s & \cdots & t_{1j}^s & \cdots & t_{1n}^s \\ \vdots & & \vdots & & \vdots \\ t_{i1}^s & \cdots & t_{ij}^s & \cdots & t_{in}^s \\ \vdots & & \vdots & & \vdots \\ t_{n1}^s & \cdots & t_{nj}^s & \cdots & t_{nn}^s \end{bmatrix} \tag{11}$$

This study uses alpha cutting effect matrix, which is normalized (hereinafter referred to as the ‘Normalized Matrix’), and by the imbalanced super-matrix, the W_w balanced super-matrix would be possible to be calculated.

$$W_w = \begin{bmatrix} t^s_{11}\times W_{11} & t^s_{21}\times W_{12} & \cdots & \cdots & t^s_{n1}\times W_{1n} \\ t^s_{12}\times W_{21} & t^s_{22}\times W_{22} & \cdots & \cdots & \vdots \\ \vdots & \cdots & t^s_{ji}\times W_{ij} & \cdots & t^s_{ni}\times W_{in} \\ \vdots & & \vdots & & \vdots \\ t^s_{1n}\times W_{n1} & t^s_{2n}\times W_{n2} & \cdots & \cdots & t^s_{nn}\times W_{nn} \end{bmatrix} \tag{12}$$

Step 3: Limit the balanced super-matrix by exponentiation of k, which is sufficiently large such as Eq. (13), so that the super-matrix is convergent and provides a constant super-matrix in the long run to obtain general vectors of prioritization or weights.

$$\lim_{k\to\infty} W_w^k = \{W^1, W^2, W^3\} \tag{13}$$

If the limiting super-matrix is not only one (more than one), so that there is N super-matrices, the mean values are obtained by summing N super-matrices and dividing by N.

4. Data Analysis and Discussions

4.1 Problem Configuration and Modeling

In the first step, the proposed model has been drawn in super decisions software (Fig. 2), which is as follows.

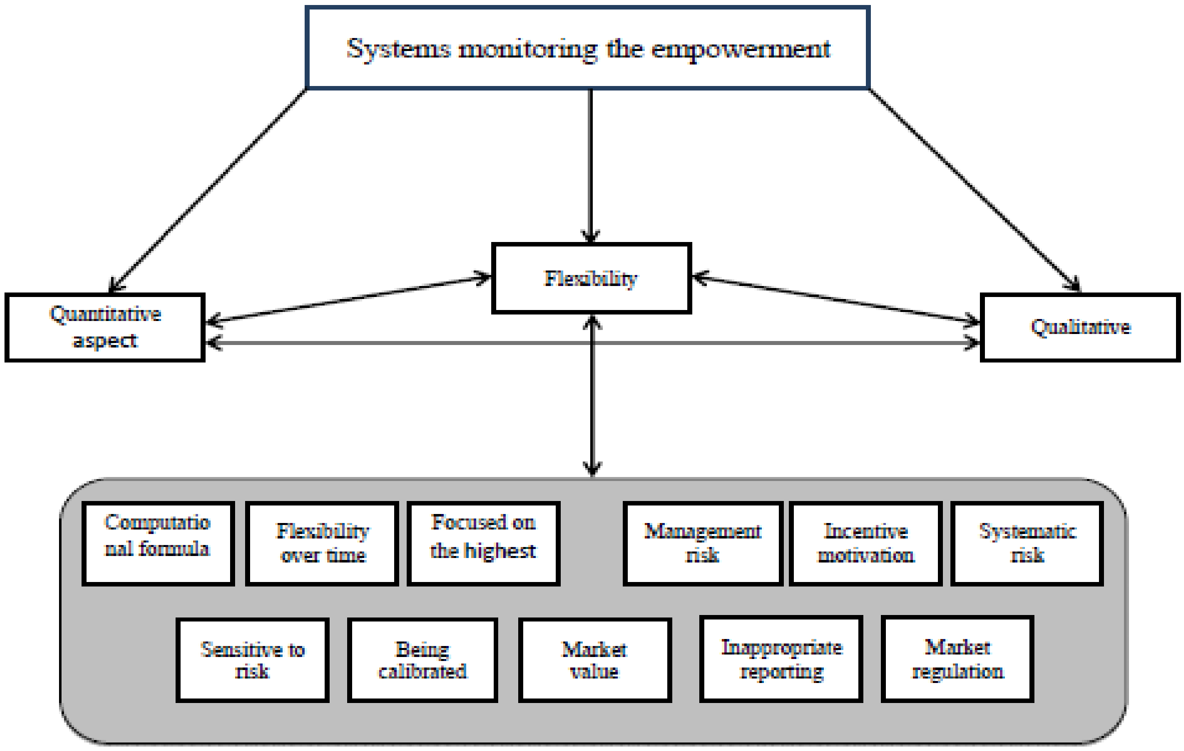

Fig. 2. Research conceptual model.

4.2 Calculation of inconsistency rate of comparative matrices and weight vectors

Following the drawing model in software, the accumulated expert data are entered into the software. According to the results obtained from the software, inconsistency index for pairwise comparisons is below 0.1. If inconsistency rate is smaller or equal to 0.1, there is consistency in pairwise comparisons. For example, as is observed, inconsistency rate is shown for comparing criteria and alternatives. As is observed in Fig. 3, since the inconsistency rate is below 0.1 (0.0536), thus, the reliability of the questionnaire is approved and there is consistency in pairwise comparisons. In this step, the final matrix is obtained by exponentiation and convergence of the balanced super-matrix. This matrix is developed from the balanced super-matrix in exponent 42. As is indicated in the final output in Fig. 4, the quantitative computational index i has the highest impact and the qualitative index has the least effect.

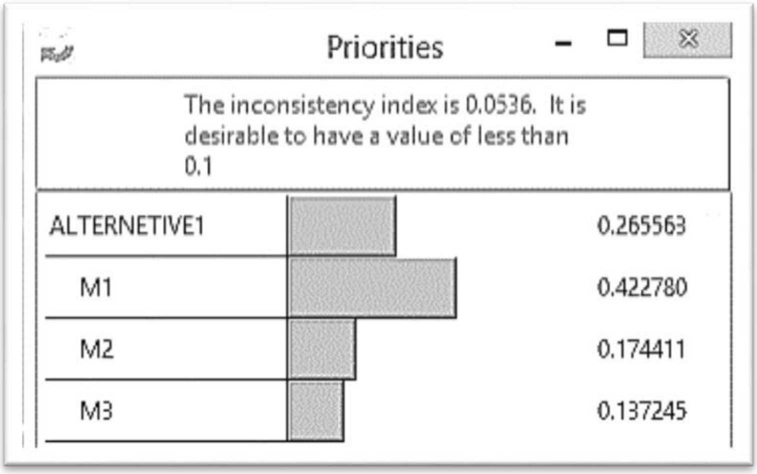

Fig. 3. Inconsistency rate for comparing criteria and alternatives.

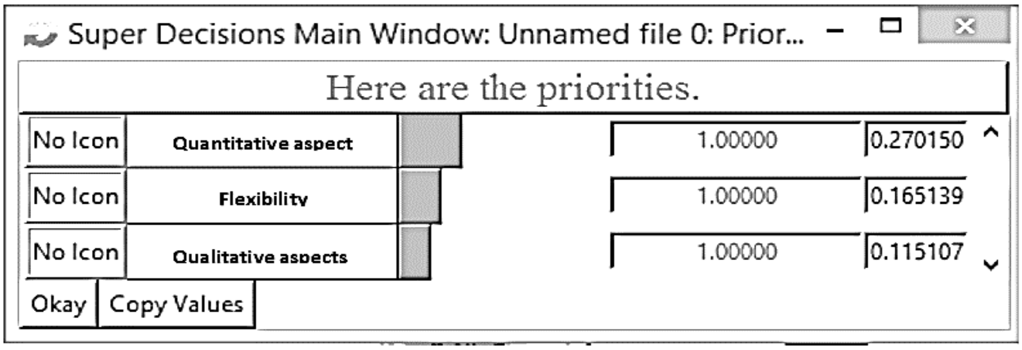

Fig. 4. Priorities index.

In order to prioritize the different systems for monitoring solvency of Iran Insurance Company by using the DEMATEL, the following steps are taken:

Table 5. Step 1. creating direct relationship matrix.

Matrix	Quantitative computational aspects	Flexibility	Qualitative aspects	Sum
Quantitative computational aspects	1	1.5	1.3	3.8
Flexibility	5	1	1.2	7.2
Qualitative aspects	3	2	1	6

Based on the points specified in the last column, the flexibility has a higher score than other variables.

Table 6. Normalization or relative strength of direct relationships.

Normal matrix (M)	Quantitative Computational aspects	Flexibility	Qualitative aspects
Quantitative computational aspects	0.1389	0.2083	0.1806
Flexibility	0.6944	0.1389	0.1677
Qualitative aspects	0.4167	0.2778	0.1389

In this step, alpha is multiplied by direct relationship matrix.

Table 7. Possible strength (invert) matrix.

Invert matrix	Quantitative computational aspects	Flexibility	Qualitative aspects
Quantitative computational aspects	1.9312	0.6377	0.5283
Flexibility	1.854	1.8508	0.747
Qualitative aspects	1.5325	0.9056	1.6579

This step is the calculation of the possible strength matrix from direct and indirect relationships, which is obtained as invert I-M.

Table 8. Total relationships or direct and indirect relationship strength matrix.

Total relationships matrix	Quantitative computational aspects	Flexibility	Qualitative aspects	Sum
Quantitative computational aspects	0.9312	0.6377	0.5283	2.0972
Flexibility	1.854	0.8508	0.747	3.4518
Qualitative aspects	1.5325	0.9056	0.6579	3.096
Column (J)	4.3177	2.394	1.9332	

According to the results of the last column, the highest score is 3.4518, which is related to flexibility, and the lowest score is 2.0972 related to the quantitative computational aspects. This step is the calculation of the relative strength matrix from direct and indirect relationships (total relationships), which is obtained as invert M (I-M).

Table 9. Indirect relationships strength matrix.

Direct relationships strength matrix	Quantitative computational aspects	Flexibility	Qualitative aspects
Quantitative computational aspects	0.7923	0.4293	0.3478
Flexibility	1.1596	0.7119	0.5803
Qualitative aspects	1.1158	0.6278	0.519

This step is the calculation of the relative strength matrix from indirect, which is obtained as invert M^2(I-M). Based on the numbers obtained from the table above, the flexibility has the highest score.

Table 10. Results.

Result	*R*	*J*	*R+J*	*R-J*
Quantitative computational aspects	3.4518	2.394	5.8458	1.0578
Flexibility	3.096	1.9332	5.0292	1.1628
Qualitative aspects	2.0972	4.3177	6.4149	2.2205

Based on the numbers obtained from the column *R+J*, the qualitative aspects have the highest impact and based on the numbers obtained from column *R-J*, the qualitative computational aspects have the least effect. According to the results and outputs of the DEMATEL software, the priority of aspects includes as follows: Quantitative computational aspects, flexibility, quantitative aspects. Following table gives the ranking of index alternatives.

Table 11. Index alternatives ranking.

Alternative	Score	Rank
Risk sensitivity	0.991	1
Computational formula calibration	0.813	3
Focus on market (economic) value	0.945	2
Simplicity of computational formula	0.731	4
Flexibility over time	0.044	11
Focus on highest bankruptcy cost	0.180	10
Taking systematic risk and financial crises into account	0.445	7
Providing appropriate incentives	0.567	5
Avoiding inappropriate reporting	0.379	9
Taking management risk into account	0.480	6
Strengthening insurer risk management and market regulation	0.430	8

According to the results, the highest score is 0.991, which is related to the risk sensitivity alternative and the lowest score is 0.044 related to the flexibility over time alternative. Among alternatives of the quantitative computational index, the priorities include as follows: Risk sensitivity, computational formula calibration, focus on market (economic) value, the simplicity of computational formula. Among alternatives of flexibility index, the priorities include as follows: Flexibility over time, focus on highest bankruptcy cost, taking the systematic risk and financial crises into account. Among alternatives of qualitative aspects index, the priorities include as follows: appropriate incentives, avoiding inappropriate reporting, taking management risk into account, and strengthening insurer risk management and market regulation. According to the results and outputs of the DEMATEL software, the priority of aspects included as follows: Quantitative computational aspects, flexibility, quantitative aspects.

5. Conclusion

Iran’s system is based on the risk and factor, which considers four groups of risk including insurance risk, market risk, credit risk, and cash flow risk. The main objection to this system is that it does not distinguish the difference between life insurance and non-life insurance; in other words, it does not propose a separate formula for calculating risk-adjusted capital for each one. There are also five levels for monitoring solvency levels consistent with the American RBC Solvency System, but the limits are set differently and less than the US system, which increases the potential to make false decisions and judgments about the financial solvency of the insurance company. According to the results, the highest score is 0.99 q, which is related to the risk sensitivity alternative and the lowest score is 0.044 related to the flexibility over time alternative. Among alternatives of the quantitative computational index, the priorities include as follows: Risk sensitivity, computational formula calibration, focus on market (economic) value, the simplicity of computational formula [21]. Among the alternatives of flexibility index, the flexibility over time has the highest priority, focus on the highest bankruptcy cost was in the second priority and considering the financial crises was in the next priority. Among the alternatives of qualitative aspects, the appropriate incentives have the highest priority, avoiding the inappropriate reporting was in the second priority and considering the management risk and strengthening the insurer risk management and market regulation was in the next priority. According to the outputs of results of the DEMATEL software, the computational quantitative aspects are in the first priority, and then there are the flexibility and quantitative aspects.

In line with the research findings, following recommendations were made:

- Holding the creativity workshops to provide incentives for employees and educate the appropriate reporting method as well as strengthen insurers' risk management and the market regulation.
- It suggested to the Iran Insurance Co. managers to take steps to smooth the staff's tasks, the systematic risk taking and the financial crises.
- It suggested to the Iran Insurance Co. managers to take steps to smooth the staff's tasks, the systematic risk taking and the financial crises.

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