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Reversibility Model against Earthquake based on Resistance Economy Policy: A Case Study in Ardabil

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ABSTRACT

Iran is placed among 10 vulnerable countries of the world in terms of threats of natural disasters. Currently, there is no reversibility model in Iran to return to the normal conditions after earthquake occurrence. This study identifies and prioritizes effective elements and develop a top option for designing a reversibility model against earthquakes. Structural equations modeling technique was employed for overlapping and Topsis algorithm was used for multi-criteria group decision making to rank the efficient and key elements for reversibility against earthquake. In designing model, system dynamics was used in the field of system analysis. As a result, the relief logistic option was selected as the top option with a large difference from other options. The reversibility model against earthquake was designed by explaining different dimensions of the top option, drawing a casual loop and entry of quantitative functions into the mathematical model. The presented model could simulate the probable condition of crisis management during earthquake occurrence in Ardabil city by selecting the order of tasks as well as the people and organizations performing the tasks and optimum allocation of resources. Since the designed model is completely dynamic, it can be utilized for predicting different earthquake intensities.

Introduction

The domestic economic conditions and the political environment surrounding Iran have characterized a special strategy in the management of national economic and executive affairs, which is referred to as the "resistance economy". The goal of a resistance economy in crisis management is to empower people and self-reliance through relying on internal capacities in order to return to balance condition. The general resistive economy policies are noted as the activation of all financial facilities and resources as well as human and academic capitals, increased power of resistance and decreased vulnerability of state economy, saving general state expenses with an emphasis on basic evolution in structures, empowerment of Jihad culture in making value added, wealth production, productivity, entrepreneurship and productive employment, determination of resistance economy dimensions and discourse making, especially in academic, educational and media environments; and identification and use of academic, technical and economic capacities to have access to defensive ability.

In crisis management, the components of resistance economy include prevention from crises occurrence or limiting their effects, prevention from additional costs, returning fast and low costs, and relying on the existing and remaining ones, including evacuation routes, safe haven locations, trained forces, water and food supplies, car service vehicles, hospitals, etc.

The objectives of resistance economy in crisis management are as follows: Rapid move, productivity, smart scientific and technical planning, providing adequate help packages, modifying the current crisis management structure, paying close attention to resource allocation, using all the capacities, fair, intelligent and targeted distribution of resources, management of consumption, comprehensive management, people-centered, knowledge-based, and economical saving and productivity, and optimization of human power.

Crisis management is influenced by various factors and it seems difficult to improve all these factors by limited resources. Hence, it is vital to find effective and underlying factors, through the optimization of which the effectiveness of the whole crisis management system can be improved. Accordingly, prioritization of key and effective factors in reversibility against earthquake and development of the top option have gained the attention of scholars in this field. Balcik, Beamon, Krejci, Muramatsu, and Ramirez (2009) conducted a study entitled achieving coordination in the relief sector to save lives and use limited resources, but efficiently and effectively, to maximize the benefits. In this regard, the solutions generated by the genetic algorithm appear to be in line with the small changes in demand and frequent trips. These results are very important at times of crisis because damaged points and frequency of travel are definitely not known at times of crisis, especially in the early hours after the crisis, which is considered a critical point.

Li, Hu, Zhang, Deng, and Mahadevan (2014) investigated the impact of critical success factors through the use of multi-attribute decision making (MADM) for identifying CSFS among the effective factors. The main focus of this research was to introduce a model for identifying CSFS among several effective factors by transforming crisis management into meaningful factors. In a research using system knowledge, Powell, Mustafee, Chen, and Hammond (2016) presented a system of system dynamics that helps analyze and identify the hazards of electrical stations at the time of a natural disaster. The valuable feature of this system is to consider the role of people as a fundamental parameter. In this model, the existing risks for a crisis in a region were analyzed and the Vensim software was used to write the model.

Johnson, Lizarralde, and Davidson (2006) presented a system dynamism approach to link design and organization via developing technical designs. Results of this research emphasized that the rebuilding function was directly related to the design and management of the project team. In fact, results of the studies clearly showed the importance of understanding the organized design of the program and project team. In other words, it emphasized that, in the emergency accommodation, technical design alone could not be enough.

Crisis is a special condition that requires the establishment of efficient logistics for the transportation of humanitarian equipment and goods in order to help victims. Effective response at this time would be of great help in reducing social, economic and environmental impacts. In this paper, an efficient genetic algorithm was proposed to address the real situation in order to investigate transportation problems. This algorithm generated relatively optimal solutions in short computing over and over again that could be used in decision making.

In the present paper, the effective and key factors for reversibility against earthquake are identified and structural equations modeling technique is used to obtain 50 factors which are then overlapped in 6 groups. Thus, it is attempted to use exploratory factor analysis to examine experimental data in order to discover and extract special and effective elements for reversibility management as well as their relationships. Afterwards, using confirmatory factor analysis, it is tested to what degree of precision the selected indexes could represent or fit the considered dimensions. Then, the 6 overlapping groups are ranked by seeking the opinions of crisis management experts and identifying 12 criteria in parallel with the resistance economy policies using Topsis algorithm method, among which relief logistic is selected as the top option. Later, considering the obtained results and using system dynamics in the fields of systems analysis, drawing casual loops and their formulation in the Vensim software, the reversibility model against earthquake is designed.

The Study

Despite the numerous threats in the area of natural disasters and gravity of Iran in the 10 countries of the world, the country has no earthquake reversibility model with special predictions or smart and scientific planning as one of the components of resistance economy in crisis management. The purpose of this study is to provide a robust economic model based on the dynamics of the system for analyzing earthquakes in order to make the best decisions on the rehabilitation of people against earthquakes. The present study seeks to answer the following questions:

- How can crisis management exist in a country, in which economy is totally government-owned and crisis management organizations use the state budget to manage the earthquake crisis with minimum reliance on state resources?
- What model can be used to include quantitative and qualitative parameters in one environment and lead to the selection of the most appropriate solution?

Obviously, based on the studies and knowledge available in the dynamics of the system, one can construct a model based on the importance of each parameter involved in returning to the state of equilibrium against the earthquake, which to an acceptable and relative extent, is responsive to all these needs.

Method

Structural Equation Modeling (SEM)

Structural equation modeling (SEM) is a multivariate and general analytical technique from multivariate regression family and extension of general linear model (GLM), enabling the author to examine a series of regression equations simultaneously.

In this method, variables are placed in some parameters so that the percentage of variance is reduced from the first factor to the next ones. Hence, variables placed in early parameters can be the most effective variables. The obtained factor is a new variable, which can be estimated through linear combination of original scores of the observed variables based on the following formulation, where w refers to the coefficient of the factor score and p refers to the number of variables:.

$$f_j = \sum x_j w_{ij} = x_1 w_{1j} + x_2 w_{2j} + \ldots + x_p w_{pj}$$

The factor analysis technique is the method to combine and summarize large numbers of variables in some different groups, which enables reduction of large numbers of dependent variables in the form of fewer latent dimensions. Factor analysis has two types including confirmatory factor analysis (CFA) and exploratory factor analysis (EFA).

As depicted in Figure 1, the researcher of a factor analysis method always assumes that latent variables are the causes of evident variables. Thus, the arrows are originated from the latent variables and end in the evident ones.

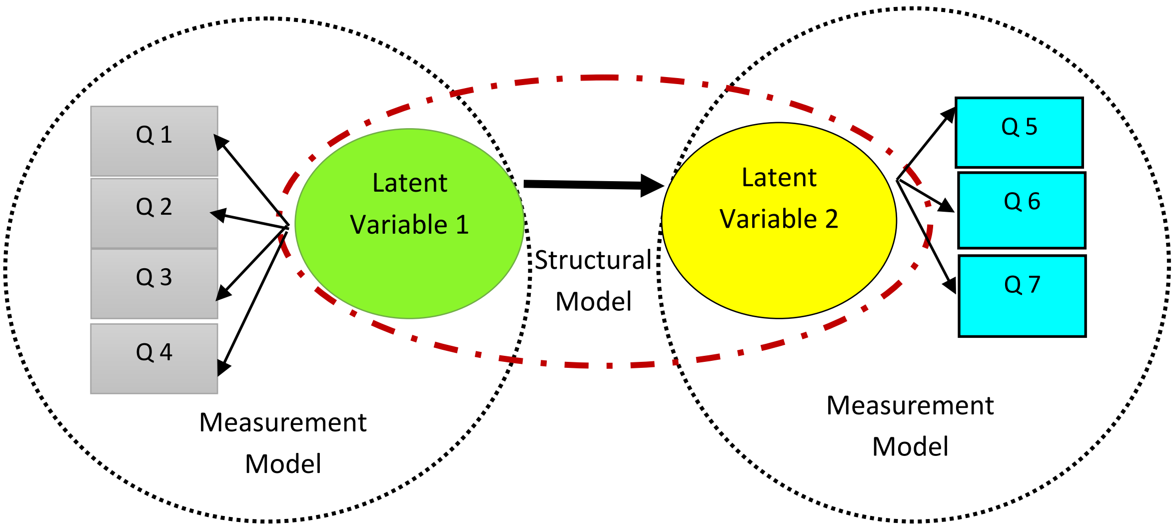

Figure1. Measurement model and structural model

* Rectangulars: represent obvious variables (observed)
* Circles: represent factors (latent variables)
* One-way arrows: represent effects of on variable on the other

Exploratory Factor Analysis

The percentage of exploration of an underlying structure is a large set of variables with the early presumption that any variable may be correlated to any factor and there is no early theory; this can be applied in cases where the author does not have sufficient evidence to make hypotheses on the number of infrastructural parameters of data and tends to explore the data based on determining the number of nature of parameters explaining diffraction of variables (Stevens, 1996).

Confirmatory Factor Analysis

Each factor is correlated to a special subset of variables, meaning that the number of model parameters has certain presumption before taking the analysis. Here, the author can also enter the expectations based on the correlations of variables and parameters.

TOPSIS Method

The TOPSIS method is used since valuation values of the options in the criteria are approximate and non-deterministic. The benefits of this approach over other spatial prioritization techniques include involving quantitative and qualitative criteria in the field of location finding, the output can specify the priority order of options and quantify this priority quantitatively, considering the conflict between indicators, the method is simple and its speed is appropriate, accepting the initial weight coefficients.

The results of this model are completely consistent with experimental methods. The response depends on the weight given to the criteria by the decision maker. The evaluation of the options and strategies identified is determined by experts according to the weights obtained in the preliminary stages for the indicators.

Step One: Determination of the importance of indicators by transport experts

In this stage, the significance of each index was determined and the vector W was formed according to Equation (1).

$$W = \{w_1, w_2, ..., w_n\} \quad (1)$$

Step Two: Conversion of the Matrix. The existing decision matrix was converted into an "unbalanced" matrix using Equation (2).

$$n_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{m} r_{ij}^2}} \quad (2)$$

Based on the multiplication of the matrix created in the previous step in the matrix, the weight of the indices was Wn × n.

$$V = N_D . W_{n \times n} \quad (3)$$

Index scores in a matrix are scalar and comparable.

A matrix is a diameter, in which only elements of its original diameter are non-zero.

Step Four: Determination of fuzzy ideal solution and fuzzy anti-perfect solving. A+ was defined for the ideal positive option, whereas A- was defined for the ideal negative option; they can be obtained using Equations 4 and 5.

$$A^{+} = \left\{ \left(MaxV_{ij} \mid j \in J \right), \left(MinV_{ij} \mid j \in J' \right) \mid i = 1,2,...,m \right\} = \left\{ V_1^{+}, V_2^{+},...,V_n^{+} \right\} \tag{4}$$

$$A^{-} = \left\{ \left(MaxV_{ij} \mid j \in J \right), \left(MinV_{ij} \mid j \in J' \right) \mid i = 1,2,...,m \right\} = \left\{ V_1^{-}, V_2^{-},...,V_n^{-} \right\} \tag{5}$$

So that

$$J = \left\{ j = 1,2,...,n \mid jRelated\ \ to\ \ profit \right\}$$

$$J' = \left\{ j = 1,2,...,n \mid jCost - related \right\}$$

Simply stated, the relevant column would be maximized if the index was profit and minimized if it was cost.

Step Five: Calculation of distance between each option and fuzzy ideal solution and fuzzy anti-ideal solution. The distance between the choice with the ideal (d_{i^+}) and the negative ideal (d_{i^-}) was calculated using the Euclidean method according to Equations 6 and 7.

$$d_{i^+} = \left\{ \sum_{j=1}^{n} \left(v_{ij} - v_j^{+} \right)^2 \right\}^{0.5} ; i = 1,2,...,m \tag{6}$$

$$d_{i^-} = \left\{ \sum_{j=1}^{n} \left(v_{ij} - v_j^{-} \right)^2 \right\}^{0.5} ; i = 1,2,...,m \tag{7}$$

The option which had the smallest distance from its ideal state and the greatest distance from its unpredictable state was chosen as the best one.

Step Six: Calculation of near coefficient index of each option. This value was calculated using Equation 8.

$$cl_{i^+} = \frac{d_{i^-}}{\left(d_i - d_{i^-} \right)} ; 0 \le cl_i + \le 1; i = 1,2,...,m \tag{8}$$

Step Seven: Ranking Parameters. Based on the descending order cl_{i^+}, we can classify the existing parameters of a given problem.

System Dynamic Method

The dynamics of the system in modern times in 1360 was designed by Addison G. Foster et al. in the Department of Management of Sloan at the Massachusetts Institute of Technology. Foster believes that the system's dynamism method integrates the power of the human mind and the ability of today's computers. One of the great benefits of the dynamic technique of the system is the transformation of quantitative and qualitative relationships into quantitative and tacit values (Félix, Branco & Feio, 2013).

Dynamics studies of the system have now become prominent in the world-class scientific and practical credibility and have been supported by academic and professional circles. In addition to teaching it in prestigious universities, professional groups from various industrial countries in Europe, Japan and the United States have been conducting applied studies in various fields (Kendra & Wachtendorf, 2003).

Despite the importance of defining the dynamics of the system in the field of system analysis, this name is not known in Iran and no significant Persian resources are available in this regard. System's dynamical methods are to make changes that you want and imagine in the virtual environment, see the result of the changes, place the results in the trial and error and, then, decide on what the best approach is for choosing (Escamilla & Habert, 2015).

System Dynamic Components

a) Feedback loops

Feedback is the process, through which a signal passes through a chain of causal relationships to re-influence itself. The initial variable, with a decrease or increase in another variable, ultimately leads to a decrease or increase in itself, like thirsty, as the concentration of salt in the body increases or controlling the room temperature in the air conditioner at the desired temperature.

b) Level and flow variables

Level variables (information elements) and flow variables (physical decisions or policies): The first variable shows the state of the system continuously (the state variable), i.e. if no changes are made to the system, that status is preserved. The second variable expresses any increase or decrease, or any change in the state of the level. As an example, the amount of water in the tanker varies between the level and amount of harvest or increase in water, the flow variable is the problem.

c) Drawing a graph for the causal loop (causal loop diagram)

The main purpose of causal loop diagrams is to show the causal hypotheses at the time of creating the model and to illustrate the overall structure of the various policies involved in the system. As illustrated in Figure 1, with the addition of several loops to each other, one can express the complete solution of a problem. The diagram should include a structure that reflects the behavior of the system.

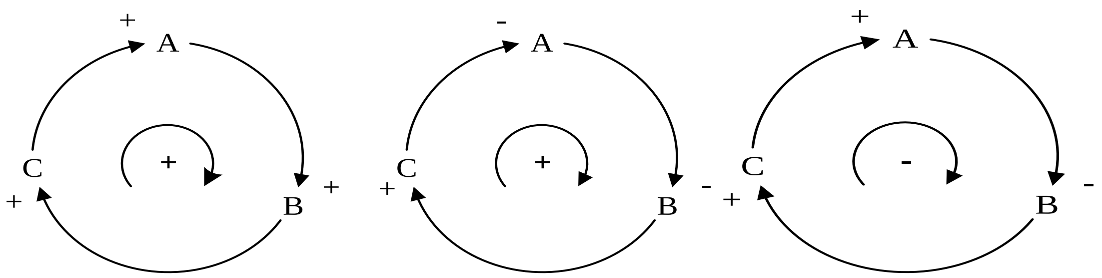

Figure 2. The casual loop diagram

Data Analysis

After studying the literature, 28 parameters were identified; nineteen parameters were identified with the analysis of examples throughout the world and in Iran with regard to resistance against earthquake. Moreover, three parameters were identified based on Yokohama's international crisis risk reduction strategy, the Hyogo framework and Sendai framework for resistance against earthquake. With the accumulation of these parameters, 50 key reversibility parameters against earthquake were identified, which are presented in Table 1. The items were regulated in the form of a 50-item questionnaire and based on 5-point Likert scale and the questionnaires were distributed among 80 employees and managers at the departments of roads and urban development, governor's general, municipality, Red Crescent, health, law enforcement, welfare and housing foundation.

Table 1
Reversibility Parameters against Earthquake

Code	Title
Q1	Lack of chaos and looting of public property [experiences of Japan 9-magnitude earthquake, 2011]
Q2	Ethical behavior and social solidarity [experiences of Japan 9-magnitude earthquake, 2011]
Q3	Use of influence of teachers on students [10]
Q4	Coordination among institutes [Bam 6.6-magnitude earthquake experiences]
Q5	Critical importance of government involvement in planning rehab (11)
Q6	Observing regulations in determination of emergency accommodation [Cuba storm, 2007]
Q7	Reduced commodity prices [Japan 9-magnitude earthquake, 2011]
Q8	Protection of properties by the government and army [Cuba Storm, 2007]
Q9	Suitable situation of relief and rescue centers [12]
Q10	Paying attention to cultural sustainability and interim housing [13]
Q11	Supporting vulnerable communities [Cuba Storm, 2007]
Q12	Distributing consumptive items [Japan 9-magnitude earthquake, 2011]
Q13	Delay in taking reconstruction [Bam 6.6-magnitude earthquake, 2003]
Q14	Using wide range facilities of the army [Sichuan earthquake, 2008]
Q15	Decreasing underlying risk parameters [Hyogo Framework, 2005]
Q16	Considering regional capabilities [14]
Q17	Using local raw materials in building accommodation [15]
Q18	Providing temporary accommodation to satisfy earthquake survivors [16]
Q19	Considering climate conditions [Ahar-Varzaghan earthquake, 2012]
Q20	Draining population of villages into neighboring cities [Ardabil earthquake, 1996]
Q21	Providing emergency accommodation in public building [Ardabil earthquake, 1996]
Q22	Provisng construction better than before for rehabilitation and reconstruction [Sendai Framework, 2015]
Q23	Determining damaged points and numbers of trips [Japan 9-magnitude earthquake, 2011]
Q24	Positioning emergency facilities [17]
Q25	Innovation of providing hemisphere shelter [Mozaffar Abad Earthquake, 2005]
Q26	Providing proper risk management [Sendai Framework, 2015]
Q27	Public participation for crisis management [Cuba storm, 2007]
Q28	Participation of citizens [Japan 9-magnitude earthquake, 2011]
Q29	Provisional warehousing position [18]
Q30	Economic reconstruction by NGOs [Mozaffar Abad, 2005]
Q31	Determining locatioins of relief centers [19]
Q32	Accessibility of emergency services through application [20]
Q33	Suitable procurement for transport systems [21]
Q34	Good procurement with determination of optimal distribution centers [22]
Q35	Providing software to estimate emergency accommodation [23]
Q36	Procurement distribution steps [24]
Q37	Determining number of demands for relief in damaged places [25]
Q38	Minimizing negative social impacts in temporary accommodation [26]
Q39	Local design and empowerment of people in building temporary accommodation [27]
Q40	Planning for urgency services [Sichuan earthquake, 2008]
Q41	Expertise-academic location [28]
Q42	Position of emergency accommodation [29]
Q43	Parameters to determine temporary accommodation [30]
Q44	Finding locations of relief centers [31]
Q45	Location and allocation of emergency accommodation [32]
Q46	Expertise location in procurements [33]
Q47	Least displacement in accommodation place [34]
Q48	Least displacement to prevent public depression [35]
Q49	Expertise location with probability of destruction of roads [36]
Q50	Using the CV tool to analyze population behavior in draining [37]

In the studied sample, as all the questionnaires were responded, no participant was excluded from the statistical analysis. The factor structure of the questionnaire was analyzed using both EFA and CFA methods.

Implementing exploratory and confirmatory factor analyses

As demonstrated in Table 2, through performing their exploratory analysis, 50 questions of the questionnaire, which were the same as 50 identified and extracted factors, were fitted to the 6 main factors. Analysis of the general model was examined in the LISREL software.

Table 2

First-Order Parameters and the Reflecting Sub-Parameters

First-order parameters (latent variable)		Indices (obvious variable)
A.	Accommodation	AQ1,AQ2, AQ3, AQ4, AQ5, AQ6, AQ7, AQ8, AQ9, AQ10, AQ11
B.	Logistics	BQ1, BQ2, BQ3, BQ4, BQ5, BQ6, BQ7, BQ8, BQ9, BQ10, BQ11, BQ12
C.	Government	CQ1, CQ2, CQ3, CQ4, CQ5, CQ6, CQ7, CQ8, CQ9, CQ10
D.	Location	DQ1, DQ2, DQ3, DQ4, DQ5, DQ6, DQ7, DQ8, DQ9, DQ10
E.	Help	EQ1, EQ2, EQ3, EQ4
F.	Pattern	FQ1, FQ2, FQ3, FQ4

Confirmatory factor analysis was performed for the model confirmation and, based on the considered fitness indices, it was placed in the standard state. Table 3 shows the fitness indices, from among which normed fit index (NFI) was not in the acceptable range, but others are within the acceptable range.

Table 3

Fitness Indices for Reversibility after Applying Modifications in the Standardized Solution

Fit indices	RMSEA	$\frac{\chi^2}{df}$	RMSR	SRMSR	CFI	NFI
Acceptable range	0.073	1.415	0.078	0.085	0.93	0.87
Acceptable range	0.05-0.08	1-3	Close to 0	<0.1	>0.90	>0.90

To achieve a more fit model with more suitable fitness indices confirming the components, the proposed model modifications were applied in order to place the fitness indices within the considered range, make all the factor loadings in the standard state below 1 and, thus, have a significant pathway. Figure 3 demonstrates the confirmatory factor analysis after applying the modifications in the standard state with 6 parameters and 50 sub-parameters, and releasing 11 covariance errors between the sub-parameters. The numbers moved from the ovals to rectangles, i.e. from latent to obvious variables (questions of the questionire), were all below 1, which could confirm the model.

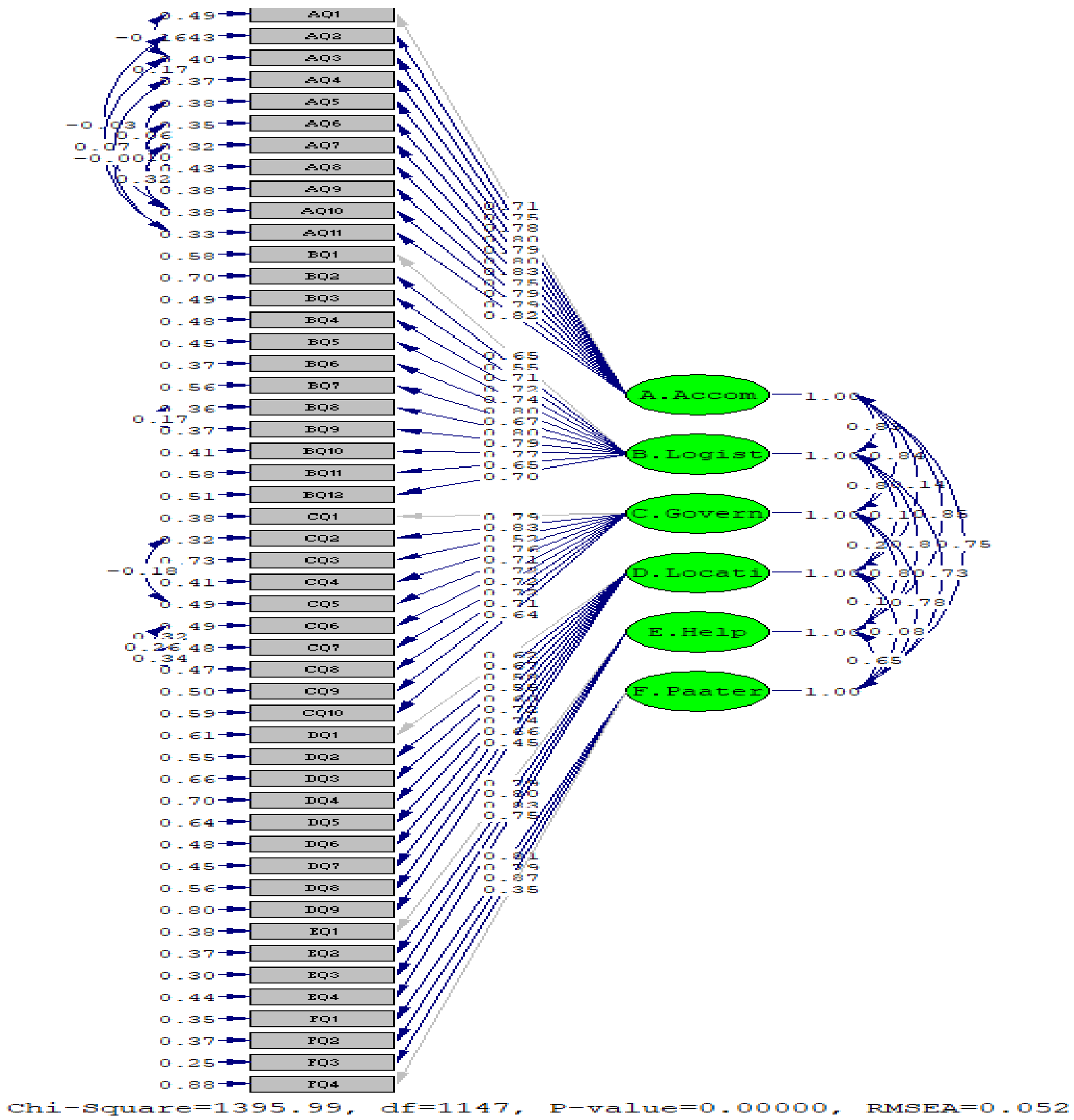

Figure 3. Confirmatory factor analysis

As depicted in Table 4, after applying the modifications, the amount of NFI index was improved and it was placed in the acceptable range. Thus, the model fitness was confirmed in this stage. It could be stated that the indices identified for each of the reversibility parameters were good fit and representations for these parameters.

Table 4
Fitness Indices for Reversibility Parameters after Applying the Modifications in the Standardized Solution

Fit indices	RMSEA	$\frac{\chi^2}{df}$	RMSR	SRMSR	CFI	NFI
Acceptable range	0.052	1.2170	0.071	0.078	0.95	0.91
Acceptable range	0.05-0.08	1-3	Close to 0	<0.1	>0.90	>0.90

Implementing the TOPSIS

A general method for measuring quality indicators with a distance scale is to use a bipolarity scale in accordance with Table 5.

Table 5

Likert Distance Scale

Degree of relative importance of the criterion	Level
9	Very high
7	High
5	Moderate
3	Low
1	Very low

A sample of the questionnaire filled out by the experts is presented in Table 6. Moreover, the weight of each criterion was determined by the crisis management experts according to their significance.

Table 6

A Sample of the Questionnaire Filled Out by the Crisis Management Experts

Criterion Option	Efficiency and minimum cost	Participation	Using all capacities	Relief	Paying attention to human needs	Safety and peace	Environmental protection	Impact on reversibility	Satisfaction	Minimum time	Reducing casualties	Using modern and indigenous systems
1. Popular and international donations	7	9	7	7	5	5	3	5	5	3	3	3
2. People's patterns of behavior	3	7	3	5	3	5	3	3	3	3	5	1
3. Government and supportive laws	3	3	5	7	7	7	5	7	5	5	7	5
4. Locations	5	3	5	3	5	5	5	3	5	3	5	9
5. Relief logistics	7	9	9	9	9	9	7	9	9	7	9	7
6. Temporary accommodation	5	7	7	5	5	5	5	3	5	3	5	7
Calculated weight (divided by 100) ($0 \leq X \leq 1$) $\sum_{i}^{m} X_i = 1$	8	7	7	8	11	9	6	10	8	11	8	7

The data collected after filling out the questionnaire were entered into the equations by the crisis management experts for obtaining the criteria and parameters. After carrying out the analysis, the results are presented in Figure 4.

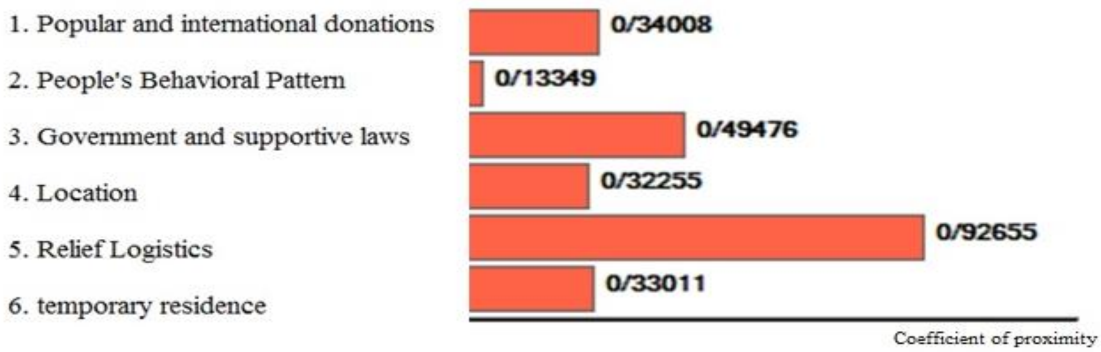

Figure 4. Results of the analysis

As presented in Figure 3, the information was obtained by merging 50 parameters identified in crisis management to 6 basic parameters. Then, the parameters were ranked based on 12 criteria using the TOPSIS model. Results of this ranking were: Rescue logistics; government and supportive laws; popular and international assistance; temporary accommodation; locations; people's patterns of behavior

Determining Damage and Losses Caused by Earthquake of 8-Mercilal Intensity in Ardebil

Estimating the extent of damage and losses in determining the vulnerability of a city against earthquakes is high and it is important to determine the volume of equipment and facilities needed for relief. On the other hand, this estimate depends on a number of factors such as type and quality of buildings, population, their distribution and distribution, etc. In Iran, the most authoritative reference in this area is the report "The Great Tehran's Seismotectonic Microzonation", prepared by Center for Earthquake and Environmental Studies in Tehran and Japan International Cooperation Agency (JICA). In this report, the charts and functions of the recovered amount of damage and losses are made in accordance with the conditions in Iran, so that it can be used for other cities and regions of the country (JICA). According to the census data in city of Ardabil in 2011, 443,154 people, 123,805 households and 116,709 residential units in the area of 6,300 ha with the population density of 77 people per hectare were in the city. Structural quality residential units (64206 metal structures (type B buildings) 28518 reinforced concrete skeletons (type A buildings), 23985 other (type C buildings) 89% of buildings in the city of durable materials 10% of buildings of type Length of durability (brick and wood with stone and wood) and 1% are durable (brick and wood) and type of building (62113 apartment units and 54596 non-apartment units) (Statistical Yearbook, 2011).

According to the mentioned materials and the estimation of the damage and losses in the possible earthquake in Ardebil, the number of damaged residential units would be 13,700 units (7,000 units; 10%, 4,000 units; 20% and 2.7 thousand units; 40%) and population of the damaged would be 43,667 people (43,217 survivors, 700 injured and 150 deaths). Based on the above estimation, the damage to residential units in the region would be 30% in the first zone (sites 1 and 2), 10% in the second zone (site 5), 20% in the third zone (sites 3 and 4) and 40%

in the fourth zone (sites 6, 7 and 8). Therefore, zones 1d 4 would be the most severely damaged.

The eight emergency accommodation sites in the four urban areas are as follows:

a) In the first zone, sites 1 and 2 located in Zarnaz Sports Complex and the beach park, each with the capacity of 250 tents or a box, to accommodate the total population of 1755 people; b) The second zone, site 5 located at Shorabil Recreation and Tourism Complex with the capacity and number of population requiring relief of 1185 people (1100 survivors, 70 casualties and 15 dead) with the capacity of 327 tents to accommodate 1,170 people; c) The third zone, sites 3 and 4 located in Rezazadeh Sports Hall, each with the capacity of 327 tents for the total population of 2340 people; d) The forth zone, sites 6, 7 and 8 located in Giral Garden, Sports Workers' Complex and Imam Zadeh Seyyed Sadruddin (AS), each with the capacity of 436 tents or a box to accommodate the total population of 4,680.

From the above statistics, 10,000 damaged units with the population of 32,018 in the form of 8943 households, due to the percentage of damage and rigidity, residential units have resettlement conditions in their residential units. They do not need emergency accommodation and relief. As the next priority, they will use loan facilities and grants for repairs. As shown in Figure 5, with the deduction of this number of major injury victims, our focus should be on the number of 11850 people in the form of 3300 households and 3700 residential units with a damaged area of over 20% who are unable to live in suitable and fixed conditions. According to the materials, the affected population will need a relief and earthquake reversal plan in the city of Ardebil for 3700 families with a population of 11850 (11,000 survivors, 700 injuries and 150 deaths). There are also available facilities in the Ardabil Red Crescent's central warehouse for the number of 2500 households with a population of 9000 for a period of one month, according to the standard, equal to 2% of the city's population.

Dynamic Studies Steps

Conceptual Step: Explaining the issue and drawing the behavior of main variables and the framework of the general model; i.e. presenting an evident definition according to the behavior of main variables, stating the goal of modeling as well as determining the closed range and system feedback structure;

Quantitative Step: Determining the type and quantity of every problem variable and parameter of the model;

Analysis Step: Computerized implementation using tests and re-evaluations in order to make the system mature;

Simulations Languages

Simulations is among the most important tools for the design and improvement of systems. Nowadays, no plane is manufactured before first comprehensively and precisely analyzing the function of its computer-based simulated model (Rajaian, 2009). The simulation software used in this study was Vensim, which is a powerful simulation tool for modeling, simulating and testing of models and analyzing the sensitivity of dynamic and complex systems.

Modeling

To perform the modelling, at first, three methods of studying the behavior of past statistics, consulting with technical and decision-making experts and reviewing the system literature were used. Then, the main duties related to the renovation and rehabilitation steps in the crisis management and function of the active sub-systems in reversibility were investigated and the local and ethnic potentials and capacities based on the resistance economy components were identified; the number of 8 casual loops were accordingly formed. Therefore, the occurrences for different parameters such as constructions, people, pathways, sub-structures, etc. were descriptively written and a dynamic hypothesis was prepared for the earthquake. Afterwards, using the investigations on the descriptive model, 22 state variables, 33 rate variables and more than 28 constant or secondary variables were extracted and placed in the model. The state variables included number of injured people and dispatched helicopters; rate variables included using the warehouses of definite provinces and hospitalized injured people; and secondary and constant variables were shakedown rate of every building and total number of destroyed building. The time range for this model was defined as 30 days after earthquake occurrence.

Loop of Injured People Needing Hospitalization

Those injured people who need special care should be admitted to the hospital after being transferred to the hospital. Otherwise, they should be taken to hospitals in other cities or provinces.

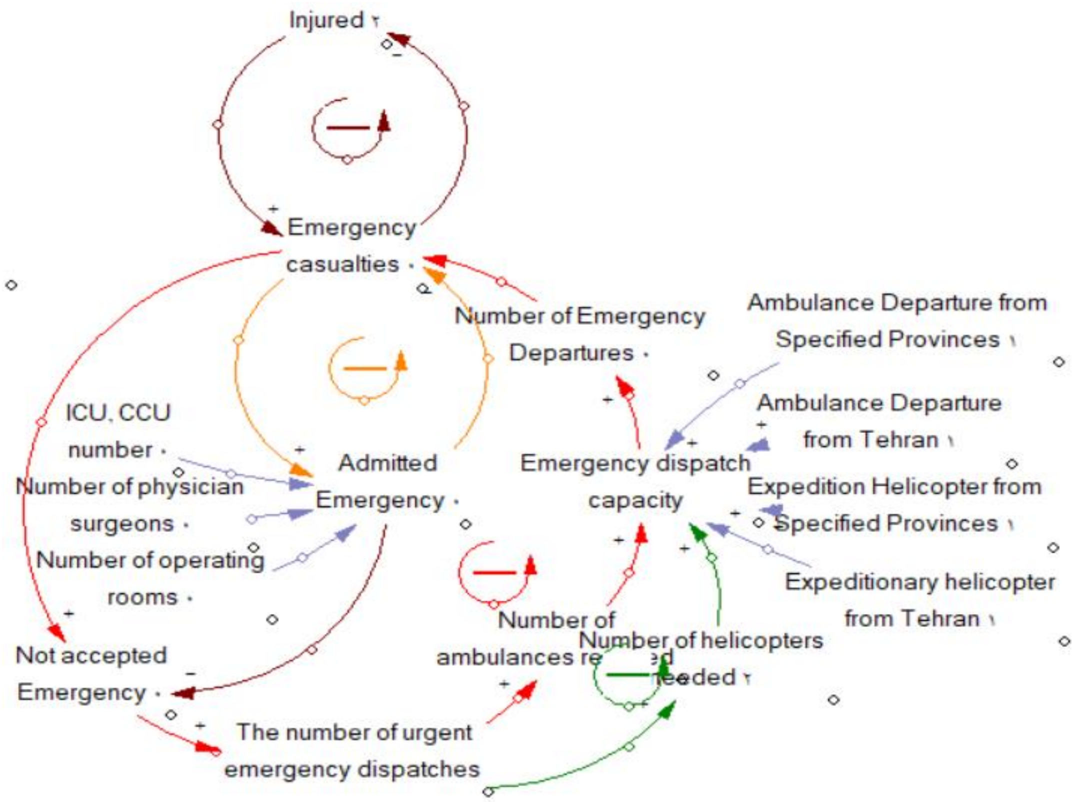

Figure 5. Loop of injured people needing hospitalization and transfer

Via the attachment of 8 created loops, one of which was explained above, causal diagram can be obtained as illustrated in Figure 6.

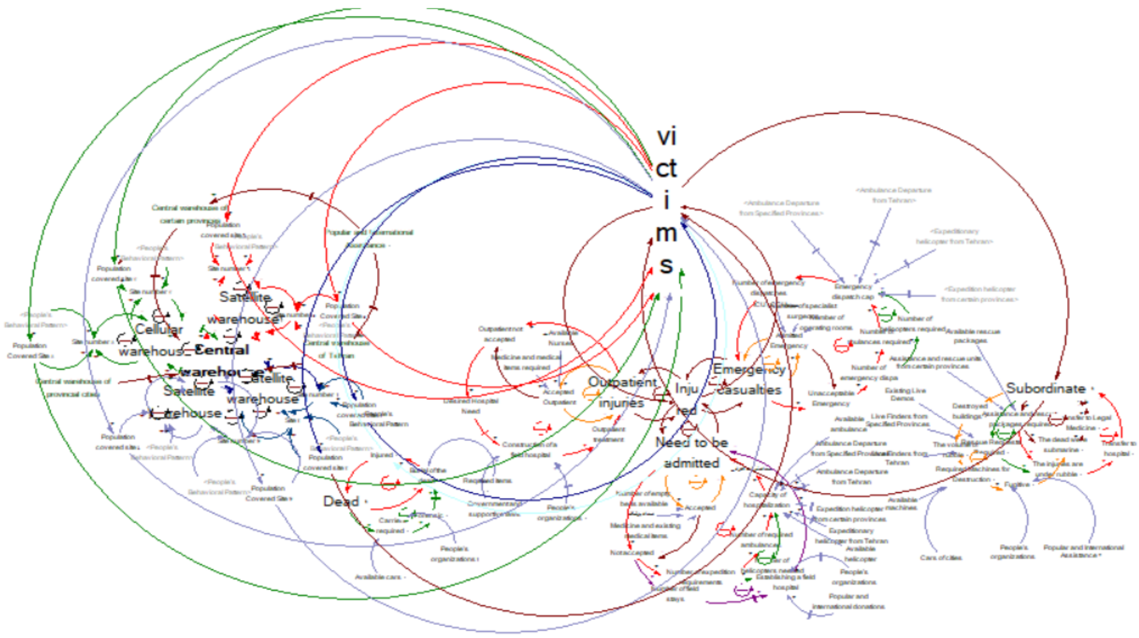

Figure 6. Model causal diagram

Formulation of the Simulated Model

Figure 7 shows the overview of the proposed mathematical model. In this stage, the model is run and the results are matched for every variable with the predicted behavior and values for that variable. In the event of a contradiction, the relationship between the variables or the equation of that variable will be reviewed.

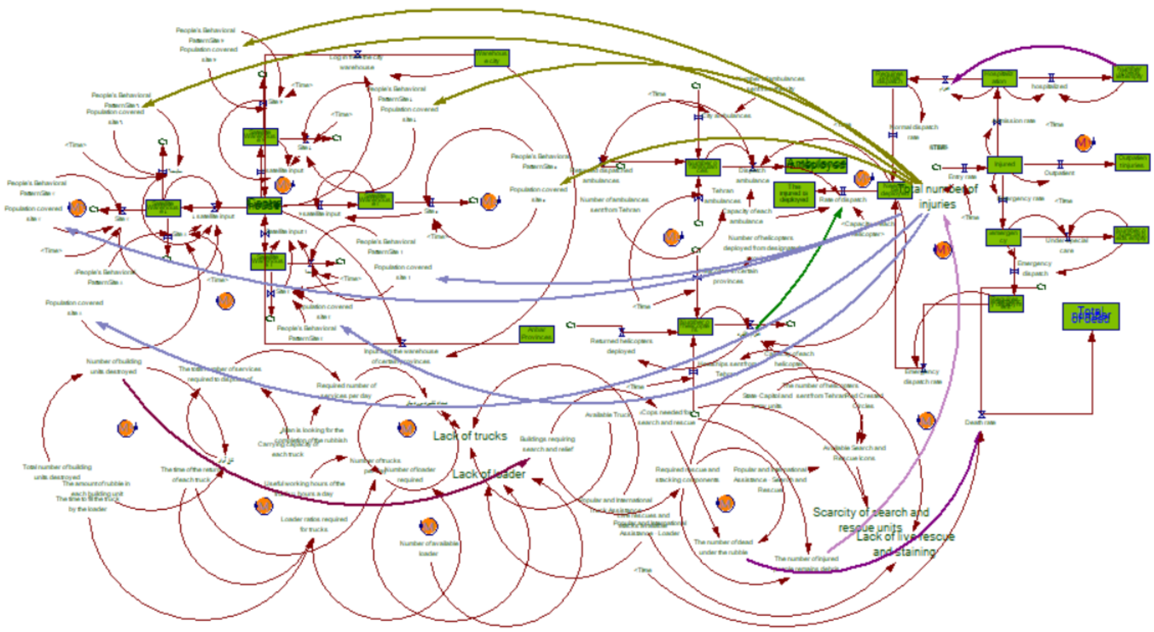

Figure 7. Overall mathematical model

By entering the values of constant variables into the mathematical model, the mode of change in the state variables and graphic variables is also obtained. Examples of constant variables include the number of vacant beds in the city's hospitals, number of available ambulances and helicopters, etc.

Among the state variables highlighted in Figure 7 in green, one can refer to the number of injured people, number of item warehouses, etc. For example, variations in the number of injured people needing hospitalization in hospitals after modeling can be illustrated as in Figure 8.

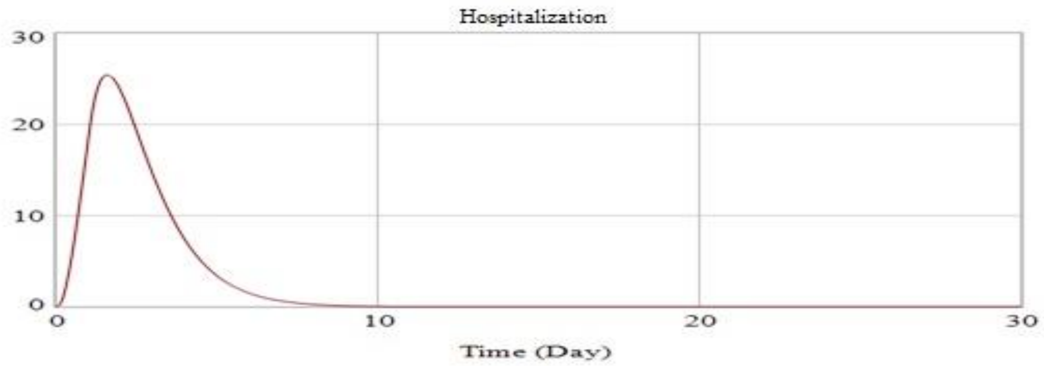

Figure 8. Number of injured people needing hospitalization

Discussion

The present study aims to identify, overlap and rank the effective and key reversibility factors against earthquake using structural equations modeling techniques and Topsis algorithm and to present a reversibility model against earthquake occurrence using system dynamics method for a top option. Among the effective factors for reversibility, relief logistics was selected as the top options with a large difference from other options. Relief logistics is considered as the backbone for all the relief operations and as one of the main relief operation activities and include almost 80% of total volume of crisis management activities. If relief logistics has a scientific and coherent system, it can help the successful crisis management via reducing the losses and the related costs. In order to solve a problem using system dynamics, first, the unacceptable behavior along with its causing or effective factors and their effects on each other and on the whole system should be determined. Therefore, the prioritization of the performed activities along with the role of main actors in the reversibility model were identified and analyzed.

After modeling, in order for the model investigation, manner of changes in the existing parameters and variables, shortage rate in every variable and manner of satisfying such shortage, the graphic diagram of all the variables should be separately investigated. Considering that the examination of all the model parameters and variables could not be managed in this discussion, the number of injured people needing special care is investigated as an example.

The injured people needing special care are admitted to the hospitals of the city in case ICU, CCU and other special care wards have enough number of beds. Otherwise, they should be dispatched to other cities of the province or the other defined provinces. It should be mentioned that the number of empty beds in special care wards located in the city is calculated assuming that 20% of the total number of special care beds of the city hospitals can be used at the time of earthquake occurrence based on the standards of Ministry of Health and Treatment.

According to the performed investigations, 30 people need special care. The number of emergency injured people and its changes during the first 30 days after the earthquake occurrence are depicted in Figure 9.

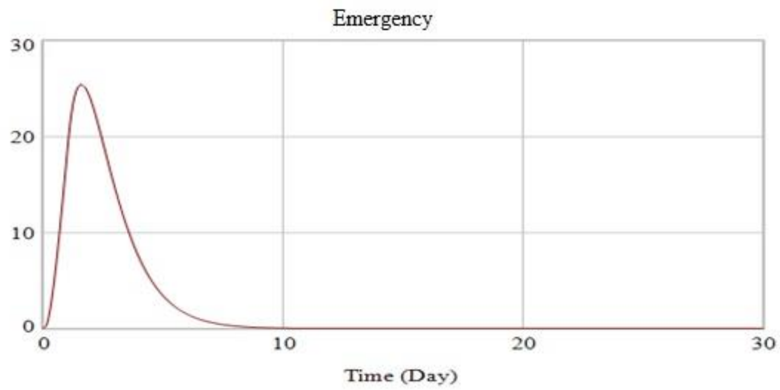

Figure 9. Diagram of the number of emergency injuries and its changes during the first 30 days after the earthquake

Assuming that 20% of the existing special care beds in the city hospitals can be used after the earthquake occurrence, the number of empty special care beds in the hospitals of Ardabil is 20 beds, the changes of which are observed in Figure 10.

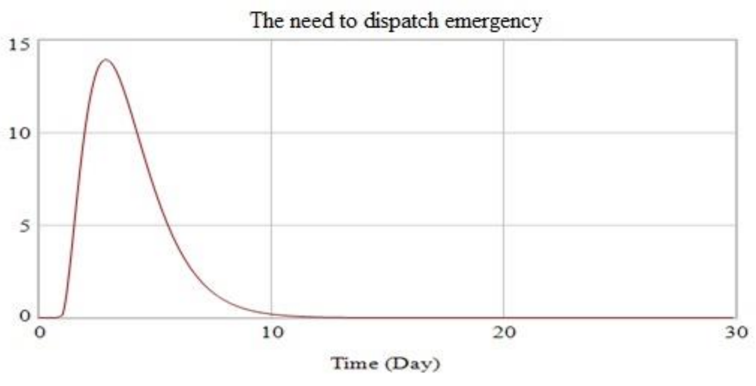

Figure 10. Diagram of the number of injuries required to be dispatched

Considering the number of injured people needing special care (30 people) and the number of empty special care beds existing in the city hospitals, a number of these injured people should be dispatched to the hospitals of other cities or definite province. These operations are done by 1 helicopter and 5 emergency vehicles. Accordingly, other variables existing in the simulated model can be observed after modeling in the form of a diagram or table and, in case of shortage in each of the parameters, its shortage rate and the satisfaction method from other cities or defined provinces can be extracted as soon as possible.

Considering the dynamics of the designed system, the model is run for the earthquake with 8-mercilal intensity and all the model parameters are investigated. Comparison of the existing variables in the model with the intensities of 8- and 9-mercilal highlighted the shortages existing in the hospital wards and other sectors. In this section, considering the existing limitations, one of the variables along with their comparison is examined.

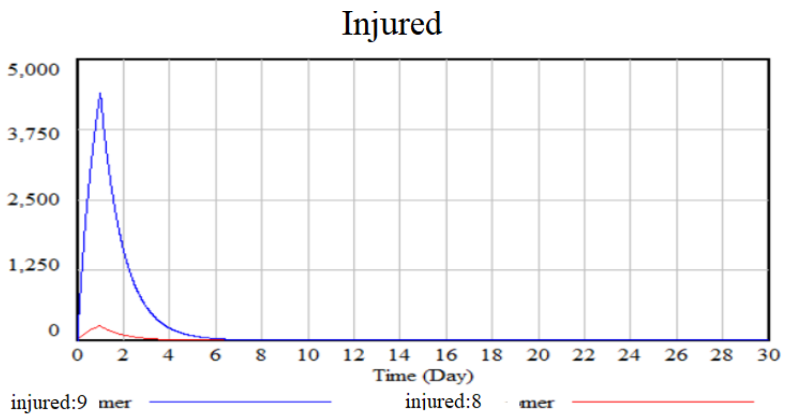

Figure 11. Diagram for comparing number of injured people after earthquake occurrence at 8- and 9-mercilal intensities

As depicted in Figure 11, the number of injured people in the earthquake at 9-mercilal intensity was far more than its number at the 8-mercilal intensity. This number was 700 and 5800 people for the earthquake at 8- and 9-mercilal intensity, respectively. Considering the number of existing empty beds in the province hospitals, i.e. 250 beds, and number of injured people in the normal state (70 people for 8-mercilal and 580 people for 9-mercilal), there was no need for dispatching to other provinces in the 8-mercilal earthquake, while the empty beds existing in the hospitals were not enough in the 9-mercilal earthquake and 5220 people needed dispatching in the normal state, as shown in Figure 12.

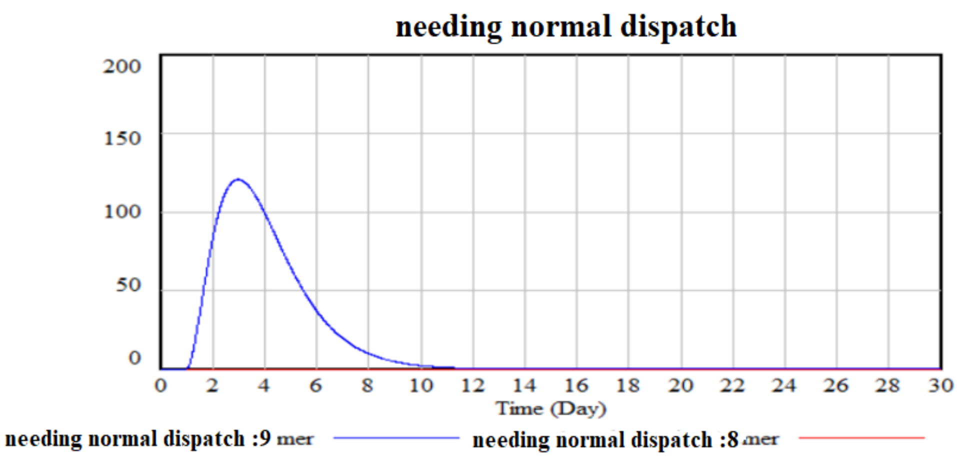

Figure 12. Diagram of comparing number of injured people needing normal dispatch after the earthquake occurrence at intensities of 8- and 9-mercilal

Conclusion

In crisis management, it is necessary for directors and experts involved in crises to have a correct pattern which could reveal the factors and their orders in terms of importance for consideration. Thus, they could increase efficiency in the use of existing equipment and minimize the psychological and physical damage induced for the people influenced by the crises. In this work, 50 factors identified by structural equations technique in the LISREL software were overlapped in 6 groups. To this end, the data obtained from 80 completed questionnaires containing 50 questions were analyzed. Then, 6 obtained parameters were analyzed and ranked by using Topsis algorithm in the TOPSIS SOLVER software and identifying 12 criteria in line with the resistance economy policies.

Then, rate of damage and losses caused by the earthquake occurrence with 9-mercilal intensity in city of Ardabil was obtained using the most accredited source existing in Iran (Great Tehran Seiesmic Microzoning Report). Through identifying the ethnic and local potentials and capacities, the reversibility model against earthquake was designed by the system dynamics in the Vesnim software.

The proposed model simulated the potential situation of crisis management at the time of earthquake occurrence in city of Ardabil via selecting the order of tasks as well as people and organizations performing the tasks and optimum allocation of the resources. Since the designed model was completely dynamic, it could be used for different earthquake intensities with different damage and also changes in the equipment existing in the city.

The performed investigations demonstrated that, despite assuming the earthquake with low intensity, shortage of special care and trauma beds in city of Ardabil could generate many problems in terms of admitting the injured people and their transfer to other cities and defined provinces. Therefore, increasing the number of special care beds and accelerating the opening of trauma hospital in the province center are among the necessities. As far as the emergency accommodation sites are concerned, the investigations showed that despite the appropriate placement, they did not have sufficient sub-structural facilities and it is essential to take measures and make special predictions as soon as possible in order to prevent the following losses and consequences in the case of earthquake occurrence. Another issue is the subsidiary warehouses existing in city of Ardabil, their settlement location and storage rate of 22 items in each of these warehouses. It is necessary for the authorities to locate and settle these warehouses based on the international standards and take measures as soon as possible.

References

Balcik, B., Beamon, B., Krejci, C., Muramatsu, K., & Ramirez, M. (2009). Coordination in humanitarian relief chains: Practices, challenges and opportunities. *International Journal of Production Economics, 126,* 22–34.

Center for Earthquake and Environmental Studies of Tehran, Japan International Cooperation Agency (JICA) (2002). The Great Tehran's Seismic Zoning. *Final Report*.

Escamilla, E. Z., & Habert, G. (2015). Global or local construction materials for post-disaster reconstruction? Sustainability assessment of twenty post-disaster shelter designs. *Building and Environment, 92,* 692–702.

Félix, D., Branco, J. M., & Feio, A. (2013). Temporary housing after disasters: A state of the art survey. *Habitat International, 40*, 136–141.

Johnson, C., Lizarralde, G., & Davidson, C. H. (2006). A systems view of temporary housing projects in post-disaster reconstruction. *Construction Management and Economics, 24,* 367–378.

Kendra, J. M., & Wachtendorf, T. (2003). Elements of resilience after the world trade center disaster: Reconstituting New York City's Emergency Operations Centre. *Disasters, 27*, 37–53.

Li, Y., Hu, Y., Zhang, X., Deng, Y., & Mahadevan, S. (2014). An evidential DEMATEL method to identify critical success factors in emergency management. *Applied Soft Computing, 22*, 504–510.

Powell, J. H., Mustafee, N., Chen, A., Hammond, M., (2016). System-focused risk identification and assessment for disaster preparedness: Dynamic threat analysis. *European Journal of Operational Research, 254*(2), 550–564.

Rajaian, M. M (2009). *Dynamic systems simulation with software (Vensim)*. Mashhad: Faryaz Publications.

Statistical Yearbook (2011). Management and Planning Organization of Ardebil Province. *Annual report*.

Stevens, J. (1996). *Applied multivariate statistics for the social sciences* (3rd ed.). Mahwah NJ: Lawrence Earlbaum Associates.