Management Science Letters 3 (2013) 625–634

Contents lists available at GrowingScience

Management Science Letters

homepage: www.GrowingScience.com/msl

# Representing a new approach for implementing e-insurance using fuzzy DEMATEL

**Mahsa Shahhosseini[a*], Zahra Arab[a], Fatemeh Khalili[b] and Zohre Taherdoost[c]**

[a]*Department Of Management, Semnan Branch, Islamic Azad University, Semnan, Iran*
[b]*Master Student of Industrial Management, Islamic Azad University, Shahrood Branch, Shahrood, Iran*
[c]*Master Student of Industrial Management, Islamic Azad University, Semnan Branch, Semnan, Iran*

**C H R O N I C L E**

*Article history*:
Received September 1, 2012
Received in revised format
1 December 2012
Accepted 5 December 2012
Available online
December 6 2012

*Keywords*:
*Electronic insurance*
*Banning factors*
*Critical factors*
*Fuzzy DEMATEL*

**A B S T R A C T**

During the past two decades, e-commerce has revolutionized many industries by providing easy access infrastructures for interested users who wish to place their orders via internet facilities. Insurance industry is one of the most important financial industries in the world. E-commerce has been attracting many in insurance industry and insurance industry has utilized e-commerce because of its own significance in economic growth and health of society. However, enhancing e-commerce into insurance firms may face serious barriers and it is important to detect and setup appropriate actions to remove them. In this paper, we present a multi-criteria decision making (MCDM) technique based on DEMATEL with an adaptation of fuzzy logic to find important factors influencing implementation of e-commerce into insurance industry. The proposed study of this paper designs a questionnaire and distributes it among five important insurance experts. Findings indicate that "behavioral-cultural barriers" influence on structural and field barriers. "Problems resulted from obeying government complicated rules" in the group of structural barriers, "low capacity of accepting e-insurance" in field barriers group and "lack of sufficient support of insurance chief managers from e-insurance and relative tendency of insurance staffs to make the insurance affairs electronic" in behavioral-cultural barriers group have the most influence on other factors of group.



## 1. Introduction

Insurance is one of the creative and forethoughtful outputs of humans to handle unpleasant incidents. The idea of security against various harmful risks has a long background. Various types of insurance protections facilitate protection of soul and property, removing tensions, life strengthening and stabilizing the economic state of family and society. Insurance industry and insurance service play essential role in economic activities such that we could certainly say that more developed and more efficient insurance market of a country will lead to improve economic welfare of countries (Skipper, 2001). There are literally different kinds of activities associated with insurance industry where e-insurance could increase their efficiencies, significantly. In fact, it can be stated that internet services

* Corresponding author. Tel: +989128320560
E-mail addresses: mahsa.shahhosseini@yahoo.com (M. Shahhosseini)


doi: 10.5267/j.msl.2012.12.007

and e-commerce are regarded as the key success of today's organizations (Ahmadi & salami, 2010). However, many insurance firms prefer not to use electronic commerce since they believe they do not have good infrastructure to operationalize it. Other insurance firms may be unwilling to use e-commerce because of lack of experience in this area (Truong & Jitpaiboon, 2008).

Now, service industry has become an active segment because of globalization rate and information technology revolution and this revolution is also resulted from paradigm change in customer requirements and expectations in the field of giving high quality services (barkur, 2007). In order to detect the traits of organizations to retain present customers, business consulters attempt to obtain necessary instruments for investigating customer satisfaction and create permanent quality improvement systems, which are accountable for customer feedbacks (CSSP, 2007).

Fast access to insurance services is one of the most important factors considered for customer satisfaction in insurance industry. In other words, people prefer to take advantage of insurance services as quickly as possible and as soon as an incident happens. During the past few years, internet facilities have created good opportunities to buy and sell different goods and services over the cyber space and this has also created an opportunity for insurance firms to present their products and services more easily. In Iran, the first attempt on providing insurance over the internet was initiated in 2001 in auto industry and it has experienced growing trend during the past few years.

DEMATEL was first presented at Battelle Memorial Institute of Geneva Research Center and it has been implemented for various complicated problems in the world such as famine, energy, environmental protection, etc. (Fontela & Gabus, 1976). DEMATEL is one the MCDM instruments and maintains the capability to convert the qualitative designs to the quantitative analysis (Lee et al., 2011). The primary objective of DEMATEL is to convert the relationships among various criteria, causal dimensions from a complex system into an understandable structural framework of that system (Dalalah et al., 2011). All criteria of a system, directly or indirectly, are mutually associated with each other in a general reciprocal system.

Zhou et al. (2011) identified critical success factors in emergency management using a fuzzy DEMATEL method. Tzeng et al. (2007) used a hybrid MCDM model to study the independent relationships of evaluation criteria with the help of factor analysis and the dependent relationships of evaluation criteria with the aid of DEMATEL. The results were capable of generating effective evaluation of e-learning programs with adequate criteria that fit with respondent's perception patterns, especially when the evaluation criteria were different.

Tsai and Chou (2009) used a hybrid model based on DEMATEL, ANP, and ZOGP to select management systems for sustainable development in SMEs. Lin and Tzeng (2009) presented a value-created system of science (technology) park by using DEMATEL. Lin et al. (2010) evaluated vehicle telematics system by using a novel MCDM techniques with dependence and feedback.

In this paper, we present fuzzy DEMATEL technique to prioritize important factors adaptation of e-commerce in insurance industry.

## 2. The proposed study

We first present details of the fuzzy logic needed in this paper.

### *2.1. Fuzzy-logic*

Many organizations adopted group decisions to determine a solution, group decision means to reach an agreement through dialogue among many experts, and in this case, an acceptable decision needs to be adopted. Of course, in such decision associated with complex systems, assessment by experts or decision-makers about a qualitative criteria object will be presented, always couched in language. The

theory of fuzzy collection can be implemented to measure vague concepts based on unreal (personal) judgments. Table 1 demonstrates change the vague judge to fuzzy triangle numbers.

**Table 1**
The correspondence of linguistic terms and values

| Linguistic values | Linguistic terms |
|---|---|
| [0.75,1,1] | Very high influence(VH) |
| [0.5,0.75,1] | High influence(H) |
| [0.25,0.5,0.75] | Low influence (L) |
| [0,0.25,0.5] | Very low influence (VL) |
| [0,0,0.25] | No influence (NO) |

Fuzzy triangle number can be a regular triplets of the form of (l, m, n) or $1 \leq m \leq n$ . For both fuzzy triangle numbers $A_1 = \{l_1, m_1, r_1\}$ $A_1 = \{l_2, m_2, r_2\}$, the arithmetic operations are performed as follows,

$$A_1 + A_2 = (l_1 + l_2, m_1 + m_2, r_1 + r_2)$$
$$A_1 - A_2 = (l_1 - l_2, m_1 - m_2, r_1 - r_2)$$
$$A_1 \otimes A_2 = (l_1 l_2, m_1 m_2, r_1 r_2)$$
$$\lambda A_1 = (\lambda l_1, \lambda m_1, \lambda r_1), (\lambda > 0)$$

In recent years, various types of defuzzy techniques have been used (Opricovic & Tzeng, 2003). In the meantime, the especial unknown and instable environment where fuzzy numbers are implemented need to be considered by choosing appropriate defuzzy technique. This study uses changing the fuzzy data into determined values (CFCS) proposed by Opricovic and Tezeng (2003) to de-fuzzy. According to process of CFCS method, first, right and left values are determined with a minimum and maximum fuzzy based on the fuzzy numbers according to the group evaluating and then the final definite number are measured in the form of average weight based on membership subject.

*2.2 The Fuzzy DEMATEL steps:*

1.Specify evaluation factors according to expert committee's opinion and research background,

2.Determine each factor influences on whole system, according to expert's opinion. To do so, we use discussed wordy expressions in Table 2 and Fig. 1. Then, we used CFC method (Eqs. 1-9) to convert the fuzzy results into crisp values.

**Table 2**
The correspondence of linguistic terms and values

| Linguistic values | [0.75,1,1] | [0.5,0.75,1] | [0.25,0.5,0.75] | [0,0.25,0.5] | [0,0,0.25] |
|---|---|---|---|---|---|
| Linguistic terms | Very high influence(VH) | High influence(H) | (L) Low influence | )VL (Very low influence | )NO (No influence |

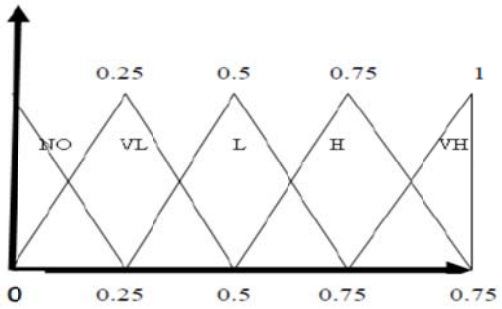


**Fig. 1.** Fuzzy triangle numbers

$$XL_{ij}^{k} = (L_{ij}^{k} - \underset{1 \le k \le k}{minL_{ij}^{k}})/\Delta_{min}^{max} \quad (1)$$

$$XM_{ij}^{k} = (M_{ij}^{k} - \underset{1 \le k \le k}{minL_{ij}^{k}})/\Delta_{min}^{max} \quad (2)$$

$$Xr_{ij}^{k} = (r_{ij}^{k} - \underset{1 \le k \le k}{minL_{ij}^{k}})/\Delta_{min}^{max} \quad (3)$$

$$\Delta_{min}^{max} = maxr_{ij}^{k} - minL_{ij}^{k} \quad (4)$$

$$Xls_{ij}^{k} = \frac{Xm_{ij}^{k}}{(1 + Xm_{ij}^{k} - Xl_{ij}^{k})} \quad (5)$$

$$Xrs_{ij}^{k} = \frac{Xr_{ij}^{k}}{1 + Xr_{ij}^{k} - Xm_{ij}^{k}} \quad (6)$$

$$X_{ij}^{k} = \left[Xls_{ij}^{k}\left(1 - Xls_{ij}^{k}\right) + Xrs_{ij}^{k} \,.\, Xrs_{ij}^{k}\right]/(1 + Xrs_{ij}^{k} - Xls_{ij}^{k}) \quad (7)$$

$$BNP_{ij}^{k} = minL_{ij}^{k} + X_{ij}^{k}\,\Delta_{min}^{max} \quad (8)$$

$$a_{ij} = \frac{1}{k}\sum_{k}^{1 \le k \le k} BNP_{ij}^{k} \quad (9)$$

A= [$a_{ij}$] is direct relations matrix of experts opinions.

3. Determine total relations matrix T- I where I is an identity matrix $n \times n$ and $T = \left[t_{ij}\right]$ representing the elements indicating the direct and indirect influences of factor $i$ on factor $j$. Now, matrix $T$ is the indicator of general relationships between each pair factor in the system. Matrix $D$ is the normalized matrix $D = \left[d_{ij}\right], 0 \le d_{ij} \le 1$.

$$D = \frac{1}{\underset{1 \le i \le n}{max} \sum_{j=1}^{n} a_{ij}} A \quad (10)$$

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

4. Calculate row summation and column summation of T matrix – $i$ row summation is indicator of all direct and indirect effects of $i$ factor on all other factors and so can call $r_i$ as the impacting degree. $C_j$ is similarly, the column summation and we can call it as influenced degree of $j$ factor.

$$r_i = \sum_{1 \le i \le n} t_{ij} \quad (12)$$

$$C_j = \sum_{1 \le i \le n} t_{ij} \quad (13)$$

Therefore, when $i = j, r_i + C_i$ shows both the influence of which $i$ factor can have on other factors of system and also the influences of other factors of system on $i$ factor. So, $r_i + C_i$ show the significant degree of $i$ factor in whole system, and $r_i - C_i$ indeed shows the influence of $i$ on system. If $r_i - C_i$ is positive, $i$ factor belong to the cause group and if $r_i - C_i$ is negative, $i$ factor belong to the effect group.

5. Demonstrate the diagram of factors influencing on $r_i - C_i$ and $r_i + C_i$ bases. This diagram is drawn by ($r_i + C_i$, $r_i - C_i$) coordinate (Huang, 2009).

*2.3 Fuzzy DEMATEL*

After making clear the main measures related to the research, the questionnaires of reciprocal effect of these features were distributed among the managers of the studied companies and then 80 of them were fulfilled by the managers of the active industrial companies process and integration the ideas so matrix of the direct relations after de-fuzzication the 1-9 equations were realized. It should be noted that the experts used the expressions of Table 2 to fulfill the questionnaire. Fig. 2 shows details of three important barriers influencing e-commerce adaptation in insurance industry.

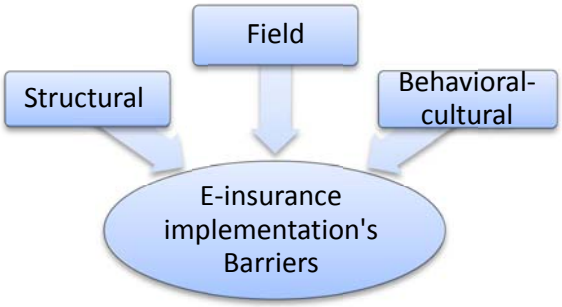


**Fig. 2.** Barriers influencing on E-insurance implementation

*Structural barriers*

$S_1$- lack of E-commerce main network in country as well as hardware and software and related applied programs,

$S_2$- depletion of appropriate communication network among branches and company agents with the center,

$S_3$- lack of standardization and nonstandard insurance policies,

$S_4$- lack of necessary civil fields for applying e-commerce including unacceptable documents and e-signs in current rules of country,

$S_5$- lack of necessary and obligatory regulations and criterions in the scope of insurance information technology,
$S_6$- problems resulting from obeying government complicated rules.

*Field barriers:*

$D_1$- limitation of communication lines and their low rate in transforming electronic data,
$D_2$- lack of developed organization and shortage of expert human force in e-insurance,
$D_3$- high cost for establishing e-commerce centers and e-insurance,
$D_4$- possibility of fraud and Money laundering in electronic sale and possibility of illegal activities of profit searching individuals in the field of internet insurance,
$D_5$- low capacity of accepting E-insurance.

*Behavioral-cultural barriers*
$B_1$- lack of belief, certainty and real willingness for application of information technology,
$B_2$- insufficient cultural filed and knowledge in identifying information technology and its advantages for managers,
$B_3$- concern for the security of e-trades and confidentiality of related personal information and customer's fear of revelation of surreptitious secrets and related personal information,
$B_4$- non comprehensiveness of computer and internet services by public or in other words lack of electronic citizens,
$B_5$- low trust between insured and insurer for e-trade of related data,
$B_6$- lack of sufficient support of chief managers for implementing E-insurance and relative tendency of staffs for making the insurance affairs electronic.

**3. The results**

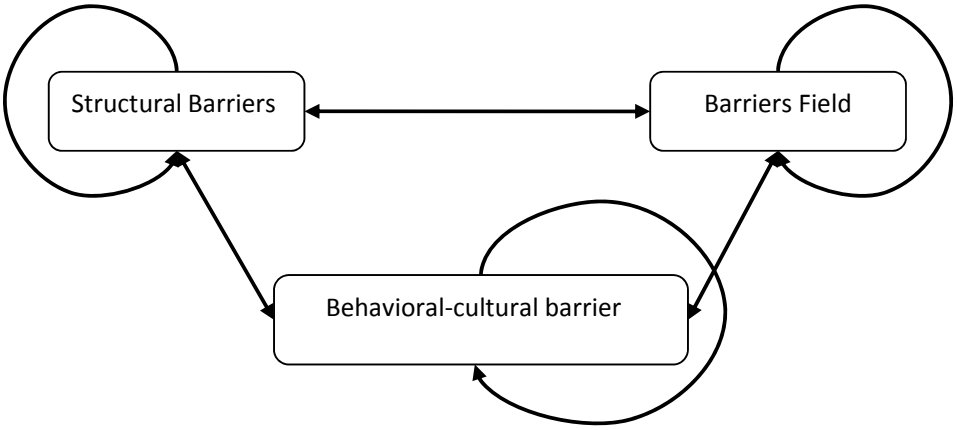


**Fig. 3.** Relationship between factors

As it is indicated in Fig. 3, each of the factors influences not only on other factors but also they have self-influence, the influence of each factor on the other factors has been investigated. In order to investigate the factors influence on each other's, the above identified factors are delivered to three university professors and 2 experts in the form of a questionnaire including oral variables (Table1). Concerning Eqs. (1-13), the findings are presented in the following Tables.

**Table 3**

Direct relations matrix A related to structural factors

| Factors | S1 | S2 | S3 | S4 | S5 | S6 |
|---|---|---|---|---|---|---|
| S1 | 0 | 0.512 | 0.004 | 0.2 | 0.004 | 0.004 |
| S2 | 0.004 | 0 | 0.004 | 0.2 | 0.004 | 0.004 |
| S3 | 0.625 | 0.004 | 0 | 0.2 | 0.2 | 0.004 |
| S4 | 0.326 | 0.512 | 0.004 | 0 | 0.004 | 0.004 |
| S5 | 0.499 | 0.745 | 0.2 | 0.512 | 0 | 0.004 |
| S6 | 0.326 | 0.326 | 0.326 | 0.625 | 0.625 | 0 |

**Table 3**

Total relations matrix T related to structural factors

| Factors | S1 | S2 | S3 | S4 | S5 | S6 |
|---|---|---|---|---|---|---|
| S1 | 0.020 | 0.263 | 0.003 | 0.117 | 0.004 | 0.003 |
| S2 | 0.017 | 0.027 | 0.003 | 0.095 | 0.003 | 0.002 |
| S3 | 0.327 | 0.144 | 0.010 | 0.155 | 0.093 | 0.003 |
| S4 | 0.155 | 0.276 | 0.003 | 0.041 | 0.004 | 0.003 |
| S5 | 0.300 | 0.480 | 0.093 | 0.312 | 0.011 | 0.004 |
| S6 | 0.327 | 0.422 | 0.176 | 0.433 | 0.299 | 0.003 |

**Table 4**

The sum of given and taken influences of structural factors

| Factors | $r_i$ | $C_i$ | $r_i + C_i$ | $r_i - C_i$ |
|---|---|---|---|---|
| S1 | 0.409 | 1.146 | 1.555 | -0.738 |
| S2 | 0.147 | 1.612 | 1.759 | -1.464 |
| S3 | 0.732 | 0.288 | 1.021 | 0.444 |
| S4 | 0.482 | 1.153 | 1.635 | -0.671 |
| S5 | 1.200 | 0.413 | 1.613 | 0.786 |
| S6 | 1.660 | 0.017 | 1.677 | 1.643 |

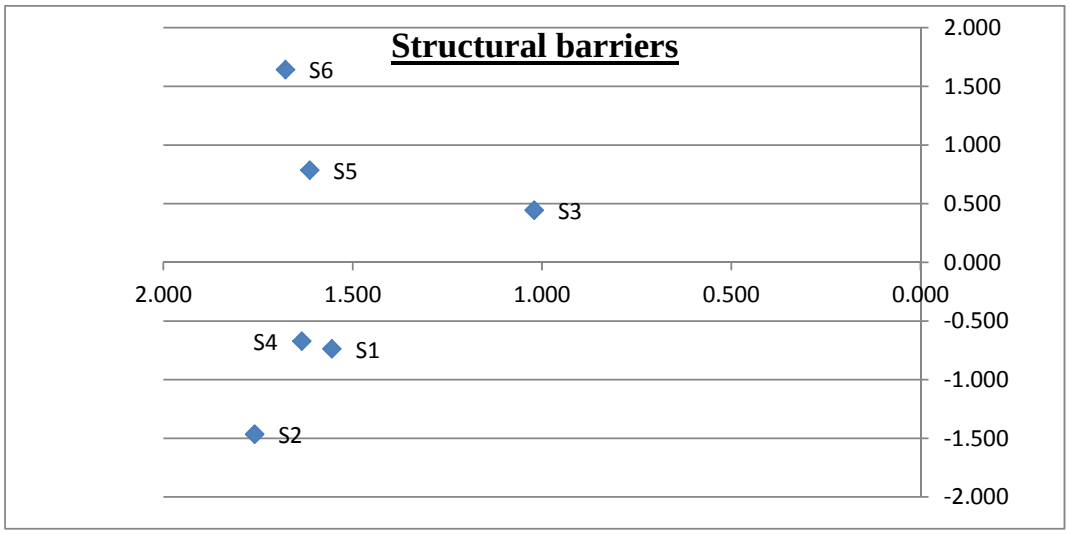


**Fig. 4.** The casual diagram of structural barriers

**Table 5**

Direct relations matrix A related to filed factors

| Factors | D1 | D2 | D3 | D4 | D5 |
|---|---|---|---|---|---|
| D1 | 0 | 0.004 | 0.511 | 0.004 | 0.004 |
| D2 | 0.511 | 0 | 0.625 | 0.004 | 0.004 |
| D3 | 0.499 | 0.888 | 0 | 0.004 | 0.004 |
| D4 | 0.511 | 0.511 | 0.745 | 0 | 0.004 |
| D5 | 0.499 | 0.326 | 0.625 | 0.326 | 0 |

**Table 6**

Total relations matrix T related to filed factors

| Factors | D1 | D2 | D3 | D4 | D5 |
|---|---|---|---|---|---|
| D1 | 0.184 | 0.216 | 0.421 | 0.005 | 0.004 |
| D2 | 0.564 | 0.322 | 0.634 | 0.007 | 0.006 |
| D3 | 0.620 | 0.727 | 0.441 | 0.007 | 0.006 |
| D4 | 0.767 | 0.751 | 0.913 | 0.007 | 0.008 |
| D5 | 0.797 | 0.699 | 0.912 | 0.191 | 0.006 |

**Table 7**

The sum of given and taken influences of filed factors

| Factors | $r_i$ | $C_i$ | $r_i + C_i$ | $r_i - C_i$ |
|---|---|---|---|---|
| D1 | 0.830 | 2.931 | 3.761 | -2.101 |
| D2 | 1.533 | 2.716 | 4.249 | -1.183 |
| D3 | 1.801 | 3.321 | 5.122 | -1.519 |
| D4 | 2.445 | 0.217 | 2.662 | 2.229 |
| D5 | 2.605 | 0.030 | 2.634 | 2.575 |

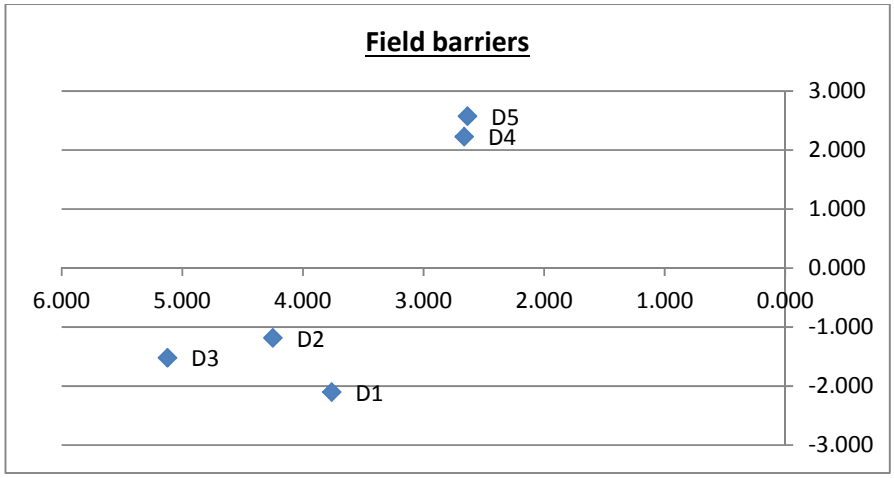


**Fig. 5.** The casual diagram of field barriers

**Table 8**

Direct relations matrix A related to Behavioral-cultural factors

| Factors | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|
| B1 | 0 | 0.511 | 0.004 | 0.004 | 0.004 | 0.11 |
| B2 | 0.819 | 0 | 0.004 | 0.004 | 0.499 | 0.888 |
| B3 | 0.004 | 0.004 | 0 | 0.22 | 0.004 | 0.004 |
| B4 | 0.004 | 0.004 | 0.422 | 0 | 0.288 | 0.004 |
| B5 | 0.004 | 0.326 | 0.004 | 0.004 | 0 | 0.004 |
| B6 | 0.625 | 0.499 | 0.957 | 0.745 | 0.819 | 0 |

**Table 9**

Total relations matrix T related to Behavioral-cultural factors

| Factors | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|
| B1 | 0.048 | 0.160 | 0.022 | 0.017 | 0.040 | 0.071 |
| B2 | 0.295 | 0.099 | 0.082 | 0.063 | 0.218 | 0.277 |
| B3 | 0.002 | 0.002 | 0.008 | 0.061 | 0.007 | 0.002 |
| B4 | 0.004 | 0.010 | 0.118 | 0.008 | 0.082 | 0.004 |
| B5 | 0.028 | 0.099 | 0.009 | 0.007 | 0.020 | 0.026 |
| B6 | 0.228 | 0.203 | 0.306 | 0.235 | 0.284 | 0.057 |

**Table 10**

The sum of given and taken influences of Behavioral-cultural factors

| Factors | $r_i$ | $C_i$ | $r_i + C_i$ | $r_i - C_i$ |
|---|---|---|---|---|
| B1 | 0.359 | 0.605 | 0.963 | -0.246 |
| B2 | 1.034 | 0.573 | 1.607 | 0.461 |
| B3 | 0.082 | 0.544 | 0.625 | -0.462 |
| B4 | 0.225 | 0.392 | 0.617 | -0.167 |
| B5 | 0.188 | 0.652 | 0.840 | -0.463 |
| B6 | 1.313 | 0.437 | 1.749 | 0.876 |

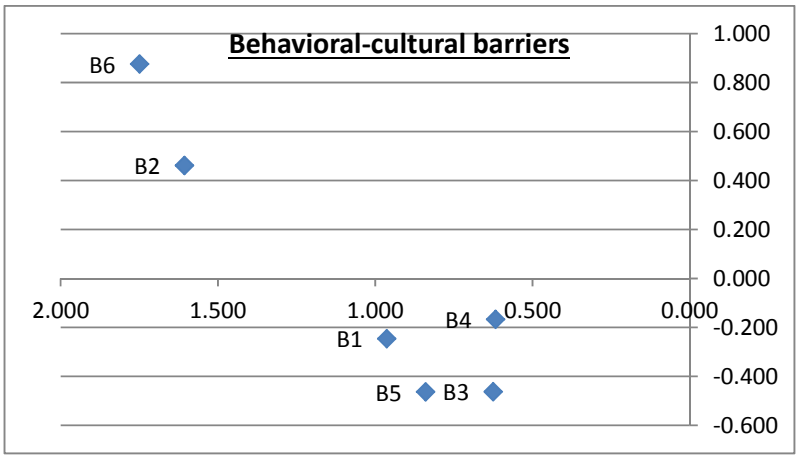


**Fig. 6.** The casual diagram of Behavioral-cultural barriers

**Table 8**

Direct relations matrix A related to total factors

| | Structural | Filed | Behavioral-cultural |
|---|---|---|---|
| Structural | 0.056 | 0.052 | 0.087 |
| Filed | 0.464 | 0.099 | 0.188 |
| Behavioral-cultural | 0.72 | 0.646 | 0.135 |

**Table 9**

Total relations matrix T related to total factor

| | Structural | Filed | Behavioral-cultural |
|---|---|---|---|
| Structural | 0.104 | 0.078 | 0.081 |
| Filed | 0.474 | 0.177 | 0.192 |
| Behavioral-cultural | 0.806 | 0.598 | 0.232 |

**Table 10**

The sum of given and taken influences of total factors

| Total factors | $r_i$ | $C_i$ | $r_i + C_i$ | $r_i - C_i$ |
|---|---|---|---|---|
| Structural | 0.264 | 1.384 | 1.648 | -1.120 |
| Filed | 0.842 | 0.853 | 1.695 | -0.010 |
| Behavioral-cultural | 1.636 | 0.506 | 2.142 | 1.131 |

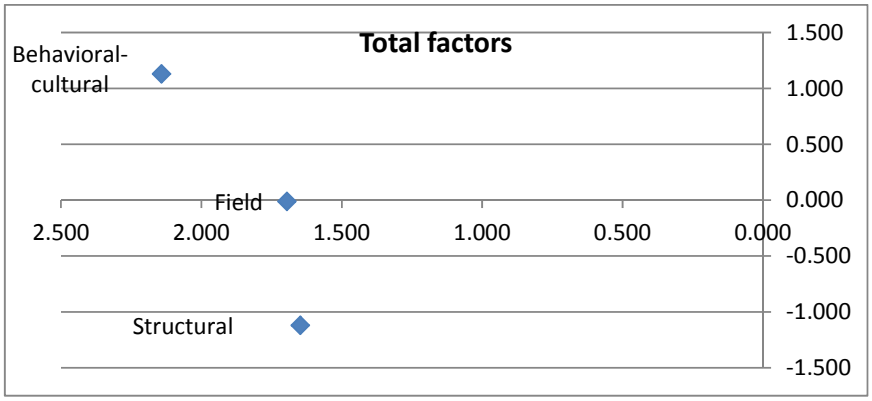


**Fig. 7.** The casual diagram of Total factors

## 4. Concluding

In this paper, we have presented an empirical study to determine important barriers for implementation of e-business in insurance industry. The proposed study of this paper designed and

distributed a questionnaire among five experts from industry and using fuzzy DEMATEL determined important barriers in three groups. Based on findings from implementation of Fuzzy DEMATEL technique we found that “behavioral-cultural barriers” have influence on structural and field barriers, therefore beliefs should be coordinated before solidification of hardware and equipment and should focus on culture and knowledge related to technologies. “Problems resulting from obeying government complicated rules” in the structural barriers group, “low capacity of accepting E-insurance” in field barriers group and “lack of sufficient support of insurance chief managers from E-insurance and relative tendency of insurance staffs to make electronic the insurance affairs” in behavioral-cultural barriers have the most influence on other factors of related groups. Identifying the main factors in implementing E-insurance will have a significant contribution to insurance chief managers because the other barriers can be elevated by indirect focus on critical barriers.

## References


Ahmadi, H., & Salami, P. (2010). Application of information systems in electronic insurance. *Research Journal of Information Technology*, 2(1), 1-6.

Barkur,G, Varambally, K.V.M., & Rodrigues, L.R. (2007). Insurance sector dynamics: towards transformation into learning organization. *The Learning Organization*. 14(6), 510-523.

CSSP (2007). Customer satisfaction: Improving quality and access to services and supports in vulnerable neighborhoods. Center for the Study of Social Policy.

Dalalah,D., Hayajneh, M., & Batieha, F. (2011). A fuzzy multi-criteria decision making model for supplier selection. *Expert Systems with Applications*, 38, 8384-8391.

Fontela, E., & Gabus, A. (1976). The DEMATEL observer. DEMATEL 1976 Report. Switzerland, Geneva: Battelle Geneva Research Center.

Gabus, A., & Fontela, E. (1973). Perceptions of the world problematique: communication procedure, communicating with those bearing collective responsibility. DEMATEL Report No. 1. Geneva, Switzerland: Battelle Geneva Research Center.

Hemmati, 2003. The Role of Insurance on E-Trade. Articles of Electronic Trade Conference.

Huang, C. Y., Shyu, J. Z., & Tzeng, G. H. (2007). Reconfiguring the innovation policy portfolios for Taiwan’s SIP Mall industry. *Technovation*, 27, 744–765.

Lin, C. L., Hsieh, M. S., & Tzeng, G. H. (2010). Evaluating vehicle telematics system by using a novel MCDM techniques with dependence and feedback. Expert Systems with Applications, 37(10), 6723–6736.

Lin, C. L., & Tzeng, G. H. (2009). A value-created system of science (technology) park by using DEMATEL. *Expert Systems with Applications*, 36(6), 9683–9697.

Opricovic, S., Tzeng, G.H. (2003). Defuzzification within a multicriteria decision model. *International Journal of Uncertainty, Fuzziness and Knowledge-based Systems*, 11, 635–652.

Skipper, H.D. Jr. (2001). *Insurance in the General Agreement on Trade in Services, American Enterprise Institute for Public Policy Research*. Washington, DC.

Truong, D., & Jitpaiboon, T. (2008). How IT purchasing preparedness facilitates e-marketplace usage. *Journal of Enterprise Information Management*, 21(2), 198-218.

Tsai, W. H., & Chou, W. C. (2009). Selecting management systems for sustainable development in SMEs: A novel hybrid model based on DEMATEL, ANP, and ZOGP. *Expert Systems with Applications*, 36(2), 1444–1458.

Tzeng, G. H., Chiang, C. H., & Li, C. W. (2007). Evaluating intertwined effects in elearning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL. *Expert Systems with Applications*, 32(4), 1028–1044.

Zhou, Q., Huang, W., & Zhang, Y. (2010). Identifying success factors in emergency management using a fuzzy DEMATEL method. *Safety Science*, 49(2), 243-252.

Zadeh, L.A. (1975). The concept of a linguistic variable and its application to approximate reasoning. *Information Science*, 8, 199-249.