Applying Mahalanobis –Tagouchi System in Detection of High Risk Customers –A case-based study in an Insurance Company

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Abstract

The organizations use all appropriate tools to improve their service to the customers. The detection of especial customers and the forecast of their behavior undoubtedly can play an important role in improvement of service. In this paper, a new statistical method called the Mahalanobis Taguchi system has been used for this purpose. This method is used for the analysis of real data of an insurance company and five big cities in Iran are considered. There are seven initial factors which is important in the occurrence of accidents and losses. These factors are reduced to four. Customer's behavior is analyzed case by case by the Mahalanobis–distance concept. In fact with using this new method, demand of customers case by case was analyzed and it is an important outcome in analyzing behavior of customers. Devising ways to prevent the accidents and damages will need the recognition of Customer's behavior. The neural networks method is used to recognize the high–risk customers, and the results of this method are compared with the results of Mahalanobis–Taguchi system. The results show that Mahalanobis–Taguchi system with its abnormality scale has a great capability in recognizing high-risk customer. To recognize the customer by the Mahalanobis Taguchi system is more accurate in comparison with the neural networks method.

Keywords: Mahalanobis – Taguchi system, Mahalanobis distance, Vehicle insurance, High - risk customers, Neural networks

Introduction

Daily increasing population and consequently increasing travels inside and between the cities has caused more car accidents and heavy financial loss and casualties and injuries which have made an inevitable care on behalf of insurance companies .Insurance companies are important organizations which can play an important role in people's convenience by providing appropriate services to them. Today, Vehicle and collision insurance organizations have outstood among all the other service presenting organizations. Detection of effective factors in occasion of an accident and inflicted damages to the vehicle and also the analyze manner of customers for detection customers that inflict a high loss to a company, undoubtedly can play an important role in planning and improvement of service and decisions. For that to take place, we have used a relative new statistical method titled: Mahalanobis – Taguchi System (MTS). This method which is in fact a mixture of Taguchi test model & the Mahalanobis Distance (MD) concept has been offered by Genichi Taguchi in 1996 in order to determine templates in different fields to classify data [1], [2]. This method is a multivariate analyses method which is for some reasons better those other methods which are common in this field [3]. Some researches and usages to already use this method are: Cudney and Colleagues to concisely present MTS method and have a review on different papers on the field [4]. In another paper, they used this method to reduce factors which are effective on the customer's satisfaction in the fields of transportation to reduce 6 factors to 5 factors [5].

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Vivek V.Khanzode and J.Maiti used MTS method to detect more important factor among 11 total factorswhich has been effective in iron casting quality [6]. Hsiao-Lin Teng and Yu-Cheng Lee used MTS method to predict financial crisis in electronic industry of Taiwan [7] and reduced the 42 effective primary detected variants to 7 factors. K.Ganesanand Mahalakshmi used MTS method to detect effective and principal factors in choosing suitable domains for fishing [8]. Chih-Ming Liu and colleagues used amixed algorithm of MTS and neural network method to process data in a dynamic space [9]. Maiti.J and Avishek Pal offered a method to improve efficiency of MTS method [10]. Shubhabarata Datta and Prasun Das used MTS in the fields of the effects of chemical compounds on metal products [11]. A.G.Olabi and EM.Anawa and also Ibrahim Sonat used this method in plastic welding and injection and brought about a satisfactory end [12], [13]. Yang T and Cheng Y-T used MTS method to improve flip-chip bumping height inspection efficiency[14].Taguchi used MTS method aimed at improving weaknesses of previous methods used in this fields [15]. Actually the Mahalanobis distance is used to establish a measurement scale and Taguchi method to optimize the target system [16]. In this paper we try to apply potentials of MTS methods to improve insurance organizations services to the customers of Vehicle Collision Insurance.

The Mahalanobis – Taguchi System has been used in various fields and has proved as a system showing acceptable results. In this paper the purpose is to show the potential ability of this method to improve insurance systems. Customers who cause high loss form a remarkable part of total loss and recognizing these customers is important for insurance companies. So in this paper, these customers were considered and **are called high-risk customers**. With results of this research, insurance companies can analyze behavior of their customers case by case, regarding their demand of company. The most important methods that are used in analyzing customer's demand are: cause and effect (regression) methods, time series and neural networks. But considering the time series models abilities, they cannot recognize a specific group of customers and then analyze their demands, because they deal with demand of whole customers. In fact, previous demands are analyzed and future demands are estimated. These customers are a minority and have higher demands, so they behave like outlier data, so multivariate regression methods are not suitable due to sensitivity to outlier data. But neural networks have binary scale and this property can be useful for this purpose. Therefore neural networks were applied for comparison with output results of MTS. To accomplish this, we used real data of customers who had their cars insured in a certain insurance company during 2007 and 2008. Using these data, important factors in a collision accident and the resulted damage was detected; and based on those; to assess validity; we detected some customers who had inflicted a high loss to the insurance company in 2008. The results show that MTS with its abnormality scale has a great capability in recognizing these customers and is more accurate in comparison with the neural networks method. In fact with using MTS, the demand of customers can be analyzed case by case and it is an important outcome in analyzing behavior of customers.

1. MTS method

1.1. Mahalanobis distance

Mahalanobis distance is a distance which was offered by P.C.Mahalanobis in1936; and is established on the base of the relation between variants of which different templates can be detected and analyzed. This is a useful method to determine the similarity between an unknown sample series and a known sample series. This distance is different from Euclidian distance by 2 means: first by maintaining the correlation between data, second by independency from measurement scale.

Mahalanobis distance for a multivariate vector x from a group of values with the average μ and Covariance Matrix S is defined as Eq.(1).

$$MD = \sqrt{(x-\mu)^T S^{-1} (X-\mu)} \quad (1)$$

If each dimension of a multi-dimension is normally distributed and after sampling these dimensions stand independent from each other, samples shape like a spherical. In such a case if we want to determine a given position of a point in this space in relation with the spherical pace, it can be judged by concepts such Average and Standard Deviation in the spherical space and comparison with the given point. But what actually takes place is that, normally in multi-dimensional spaces, all spaces are connected one another and not independent. In such a situation, normal distributions are or in linear relation or there is no relation between them; so there is a linear relation between them and in fact there is a correlation between them. In such a situation, the resulted space is elliptical due to the correlation; so in such a case in the relative angle of the point in relation with space is important in addition to average and standard deviation. In other words, the density of points in an elliptical space has also to be considered.

Here was applied covariance matrix between the elliptical space points and bring up Mahalanobis distance concept. In figure 1, Mahalanobis distance which is a direct distance similar to Euclidian distance but differentiates the densities between points in space, is shown .the Mahalanobis distance is calculated in relation with the centre of points which create the elliptical space. This elliptical space is called base or normal Mahalanobis space.

1.2. Taguchi design of experiments

In 1940, Dr.Taguchi brought up new statistical concepts and latters on these concepts proved useful and precious in fields of quality control and development .since the time, many Japanese industrialists take up the method to improve process and product quality. The enhancing quality of vehicles made in this country is strongly involved with widely use of the method. To design of experiment, Taguchi applies some standard tables named orthogonal table or matrix .e.g. If there is 7 factors each in 2 levels, i.e. 128 tests, he use standard table L8. We use these orthogonal tables in required calculations in this paper. 8 designed tests are shown instead of 128 tests. Taguchi says in case that all factors have 2 levels, factors could be accidentally positioned in columns .since, in MTS method only 2 level is justified, here, only a simple 2 level form is considered. To continue the design of experiment, after design of details according the orthogonal tables, the result of each test is to be determined and after that according to the result we should make decisions. This step brings up the concept of Signal to Noise Ratio.

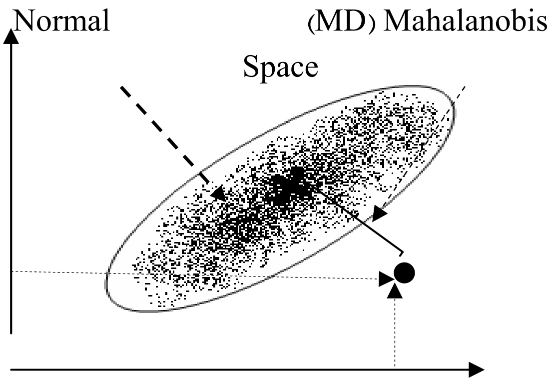

Figure 1: Mahalanobis Space and Distance

1.3. Signal to Noise Ratio

A repeatedly experienced test, if possible, should increase the accuracy. Here the concept of the Signal to Noise Ratio is useful and used to make decision. But if in any case it was impossible to repeat the test or it was non-economic to repeat it, we should go on analyses only with the same result. The concept of the S/N Ratio is calculated; taking the average of squared deviation from target into consideration and is formulated so that the greater this value is, the better the result of the test would be. The factor level which caused to increase the ratio, have to be considered as desirable level. In the definition of the quality of product or process, the quality index is one of the 3 form which follows: The greater is the better. The closer to nominal value is the better. The lesser is the better.

The way to calculate the average squared deviation from the desirable value in each case is like this:

The greater is the better:

$$MSD = \frac{\left(\frac{1}{Y_1^2}+\frac{1}{Y_2^2}+\dots+\frac{1}{Y_N^2}\right)}{N} \qquad (2)$$

The closer to nominal value is the better:

$$MSD = \frac{[(Y_1-\mu)^2+(Y_2-\mu)^2+\dots+(Y_N-\mu)^2]}{N} \qquad (3)$$

The lesser is the better:

$$MSD = \frac{[Y_1^2+Y_2^2+\dots+Y_N^2]}{N} \qquad (4)$$

In the formula above, Y_i stands for the results of N time repetition of each test of orthogonal table. After calculation of the related MSD, the ratio of S/N is resulted from the following formula: So for each test a certain value of S/N is calculated through Eq(5):

$$SN = -10 \log (MSD) \qquad (5)$$

1.4. The Optimal case Selection

For each factor, the SN values in test with level 1 factor sum up together and their average is calculated; and same as this will be acted for level 2. Now there are 2 average SN value for each factor: for level 1 and level 2. This will go on for all the other factors. Based on this criterion that The More Ratio of SN is the better, the decision making will be. The level of factor which has increased the ratio will be selected as desirable level. This way, the desirable level of each factor will be selected. For being sure of the accuracy of the process, the optimal test is done, and the result will be considered to see if the answer is OK.

1.5. Procedure to accomplish MTS method:

When we need to make decisions about a case in which there are a lot of effective factors and these factors are highly correlated to each other, actually a multivariate analysis is done, in such cases it is very recommended to make the decision with lesser factors and higher accuracy. MTS method in fact is a sampling method which does this task by analyzing of sampling data .Taguchi describes the procedure as consisting of some steps [17]:

Step 1: Definition of a normal group; at the first step the data to be sampled have to be divided into 2 groups – Normal and Abnormal. For example if economic analyses of companies are to be done, the first group can include successful economical companies and the second group can include the bankrupted economical companies. If the decisions are to be made about disease diagnosis of individuals, the first group stands for healthy people and the second for patient ones at the special diagnostic field.

Step 2: Definition of variables; factors effective on a special case which is to be studied will be determined associated with expertise.

Step 3: Production of a data base from normal group for the selected variants i.e. a sample have to be derived from the first group (for example n members) for the determined variables (for example K factors).

Step 4: MD value is calculated for every individual of the normal group.

1.5.1. How to calculate the Mahalanobis Distance

- After data collection, the standard deviation and average of data is calculated for each item and all data get normalized. If x stands for rare initial data, μ stands for the average value of the item and σ is the standard deviation of the item then each data is normalized as Eq(6):

$$Z = \frac{(x-\mu)}{\sigma} \qquad (6)$$

- Since each individual has K items, so is calculated K normalized value for each healthy people

- Taking normal data into consideration, now the correlation matrix between items (variables) is calculated
- To calculate the Mahalanobis distance, the previously calculated matrix is converted
- the Mahalanobis distance for each individual could be calculated through Eq(7):

$$MD = \frac{1}{K} Z\, A^{-1} Z^{T} = \frac{1}{K}(Z_1, Z_2, \dots, Z_K)\, A^{-1} (Z_1, Z_2, \dots, Z_K)^{T} \qquad (7)$$

Step 5: collection of K variables for the samples outside the normal space (for example r member)

Step 6: MD value is calculated for all samples outside the normal group

Step 7: The discriminative power is assessed. After drawing the sample diagram in MD if healthy people's MD has the lesser and patient people's MD has the greater values the results are valid. This acceptable difference for the 2 groups is different in different questions.

Step 8: MTS is optimized. The variables are dedicated to 2 levels. Level 1: the variable is used. Level 2: this variable is not used. For each test the MD values for abnormal individuals is calculated. In fact each test is repeated up to the number of individuals in abnormal group i.e. r times. SN ratio is used to assess the discriminative power. The average of the SN of each factor in levels 1 and 2 is calculated. After that with the criterion: the More is the Better, judgment according SN values is done. The way to judge is as follows:

- If SN value for a variable in level 2 is more than in 1 i.e. the variable is not used, then the discriminative power increases.
- If SN value for a variable in level 1 is more than in 2 i.e. the variable is used, then the discriminative power increases.
- If SN value for a variable in level 1 is equal to what in 1, it has no effect on the discriminative power.

2. Application of MTS method in detection of effective factors in vehicle damage

2.1. Insurance Organization and Multivariate Analyses

When there are too many effective factors in a system, and not independent to each other and influence each other, then the analyses of the system gets complicated. In such a condition usage of multivariate analyses is necessary, so that we can simplify the system and make more understandable, using detection of more important factors. The MTS method is a suitable multivariate analyses method to reduce effective factors and detection of principal and more important factors. Since in case of inflicted damages to automobiles, there are many effective factors and all these factors effect each other also in turn, here we are faced with multivariate analyses again. According to the Car Collision experts, 7 factors are already detected to affect inflicted damage to a car:

- the driver's *Age*
- the driver's *Sex*
- *Record* of driving
- *Age* of the car
- *Model* of the car
- *Price* of the car
- the *City* in which the car is used

This is clear that, these factors affect also each other in turn. e.g. *Age* and *Sex* can affect the *Model* of the car when the buyer wants to buy it. To analyze the real factors effective in accidents and damages, we used the MTS method.

2.2. Application of MTS method in Insurance industry

All the procedure was accomplished as follows:

Step 1: To define a normal group; at this step we created 2 classifications: Normal and Abnormal. To do so, we used real data of customers who had their cars insured in 2007 at an insurance company. Since the factor of *former record*, seems to be an important variable in this field, we took customers who had already a record in this company into account. This analysis was held up for customers whose car was motorcars and used for personal use. The normal group includes customers who've been lucrative for the company and the abnormal group the ones whose car has been damaged which costs more than the insurance premium paid to the company .i.e. the insurance company has incurred loss. Now this loss can be ranked from lowest to highest.

Step 2: To define the variables; according to insurance experts, there are 7 variable and effective factors. To put the method practice, all the factors have to be quantities:

The driver's Age: this is a quantitative variable which is used as what it is.

The driver's Sex: it is qualitative, so to insert the factor, we use 0 for male and 1 for female.

The Record of driving: Customers, who have no records of damage and have been granted a discount, are defined as clean-record customers and quantified as **0**. On the other side the customers who inflicted loss to the insurance company because of their damaged car are defined as bad-record customers who are quantified as **1**.

The Life length of car: the number of the years since the car has been purchased from the company, which is a quantitative variable and is used as what it is.

The Model of the car: for this, we chose 10 motorcars mostly popular among citizens through whom we could increase the efficiency of the analyses and to cover wider community. This variable is also qualitative. To quantify it, we used numbers **1 to 10** each assigned accidentally to each model.

The Price of the car: this variable is also quantitative and could be used as unchanged.

City: cities in which the car is used include 5 great cities of IRAN named Tehran, Esfahan, Shiraz, Mashhad and Rasht .this variable is marked by the numbers **1to5**.

Here is a problem and that's to say, the cars may be used by persons other than the ones who are insured by the company. This increases error in calculations. If this point had been exactly chased and recorded the accuracy would have been very higher. Factors and their ranges are summarized in table 1.

***Step3*:** To product a data base of the normal group for the selected variables, 600 normal samples were randomly derived out from all the customers of the insurance company.

Step 4: the MD value for each individual of the normal group was calculated.

Step 5: Collection outside the normal space.200 abnormal samples were randomly chosen.

Step 6: the MD value for all the samples outside the normal group was calculated.

Step 7: assessment of the discriminative power. In figures 2 and 3 the Mahalanobis distance of the 2 normal and abnormal groups is shown.

Factors	The driver's Age	The driver's Sex	The driver’s Record	the car’s age	The car’s model	The car’s price	city
Domain	23-83 years old	0 , 1	0 , 1	0-8 years old	10 model	3500-37000 $	1-5

Table 1: Factors and their domains

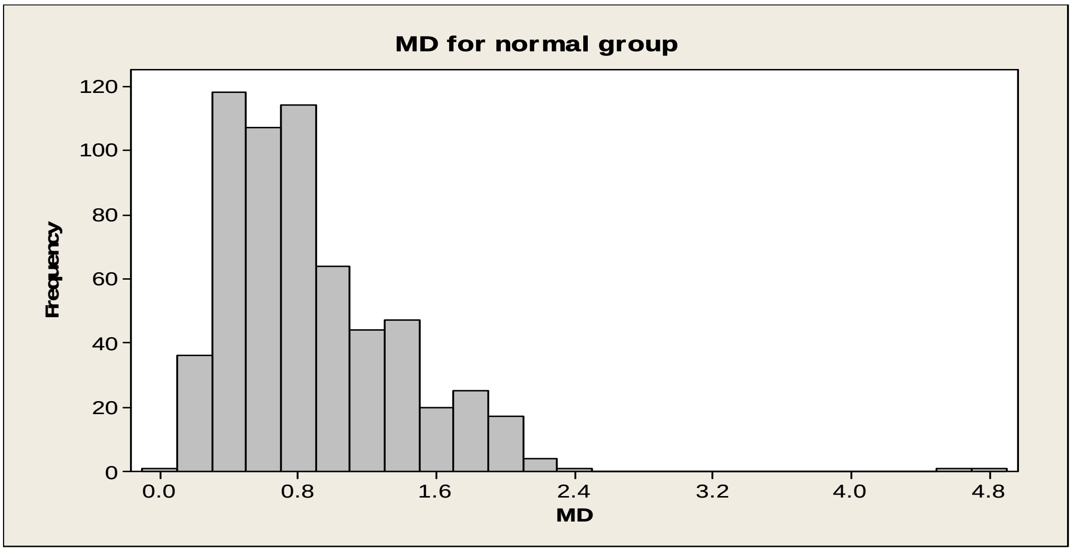

Figure 2:. Mahalanobis Distance of normal group

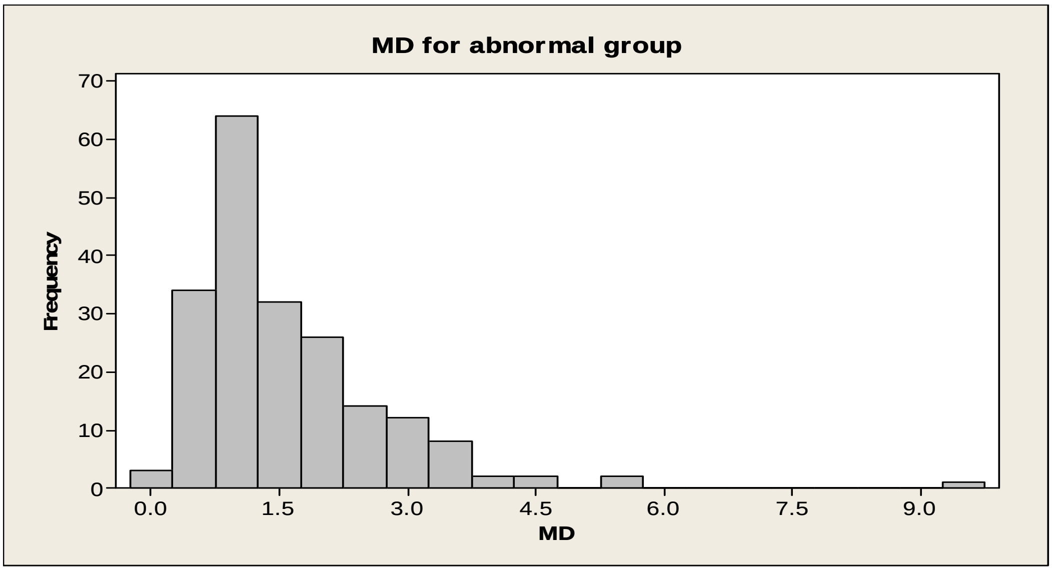

Figure 3: Mahalanobis Distance of abnormal group

Taking the proportion of the chosen samples into account as what is shown in these figures the Mahalanobis distance for abnormal data was greater than normal ones. Although the difference and the discriminations are not that much, in such system seems to be acceptable. What has to bring up here is that an acceptable discriminative power is different for different systems or different means. In cases like disease diagnosis in which the MTS method has been used the discriminative power has been very high and finally fit to the job of differentiation between healthy ones and the patients. And the error type 1 and type 2 both has been very low

But what is important about the illness case is that an individual, who has difference in factors from the normal case, is highly probable to be patient, according to the standard mood and structure of human's body. While at the Insurance case, although an individual is different rather than the normal group in all his variables, but we cannot judge him for sure as having an accident case at future and would be a loss-inflictor customer then. This is in fact a difference between the case of insurance with some other cases and the accuracy of the test would be lesser than the case of illness. So in this step although the difference of Mahalanobis distances of the 2 groups are not at the same level with the illness diagnosis, but is acceptable and we can continue the process

Step 8: MTS is optimized. Variables are assigned to 2 levels. 1 means the factor has not to be used and 2 means the factor can be used. Since there are 7 variables, so to design of experiments, we used the L_8 orthogonal tables of Taguchi. For each test the distance for all 200 abnormal samples and then for each test an SN Ratio, was calculated .the summary of these results is shown in table 2.

2.3. Selection of effective factors

As it was mentioned before to choose an optimal form we have to calculate the average of SN in levels 1 and 2. Then with the criterion: "the more is the better" taken into account, and according to SN values the judgment is done .the summary of the average taking of the factors is shown at the table 3.

The procedure to make decision is like this:

- If the average of SN of a factor in level 1 is greater, that means that the factor has to be used at the level i.e. to be chosen
- if the level 2 is greater , that means the factor must be eliminated and the factor has no effect and it complicates the discrimination or detection

Figure 4 shows the ascending and descending SN course of action for the factors.

The driver's *Age*, the driver's *Sex*, the driver's record and *Age* of the car has a descending course of action. That means these factors should take place in level 1 so that make it easier to discriminate and detect two groups. Level 1 means the variable must be used. So these variables are effective and must be considered in analyses. City as a variable has a total descending course of action and that means this variable can bring about errors in discrimination and detection and must get eliminated. The two variables Model and Price have approximately a horizontal course of action i.e. usage or misusage of these variables has no effect on discrimination in these 2 groups and to have a better procedure have to get eliminated. So among the 7 variables which were initially considered as effective, only 4 variables were finally selected. As you saw, human factors including: Age, Sex, Record, and only one non-human factor i.e. age of the car are effective factors. So, here human factors can prove as being more important. The summary of the Mahalanobis Distance of the some customers before and after optimization is shown at the table 4, 5. Mahalanobis Distance before than optimization for normal group is smaller than after. And this Distance before than optimization for abnormal group is greater than after optimization. And it shows that MTS method is useful for this system.

	age	sex	city	model	Car's age	record	price	SN
Test 1	1	1	1	1	1	1	1	-2.03
Test 2	1	1	1	2	2	2	2	-13.27
Test 3	1	2	2	1	1	2	2	-15.43
Test 4	1	2	2	2	2	1	1	-19.88
Test 5	2	1	2	1	2	1	2	-15.37
Test 6	2	1	2	2	1	2	1	-12.48
Test 7	2	2	1	1	2	2	1	-39.91
Test 8	2	2	1	2	1	1	2	-26.68

Table 2: Taguchi L8 orthogonal table and SN ratio

Average of SN in 1 level	-12.654	-10.792	-20.476	-18.187	-14.157	-15.99	-18.577
Average of SN in 2 level	-23.612	-25.475	-15.791	-18.079	-22.11	-20.26	-17.69

Table 3: Average of SN of factors in level 1, 2

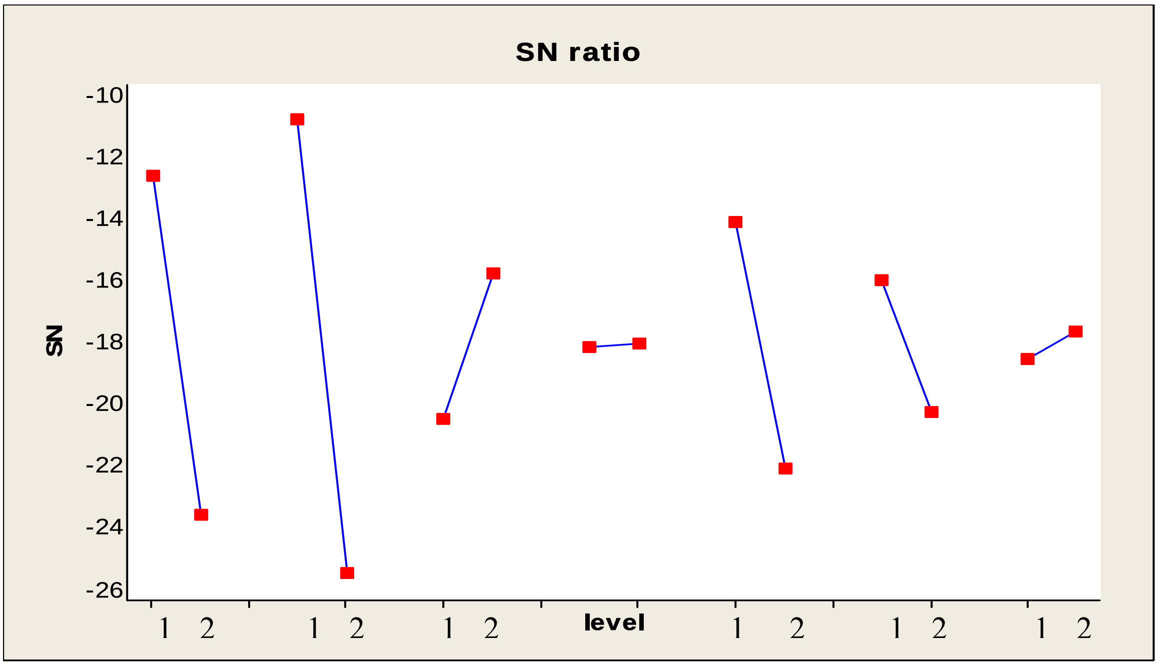

Figure 4: The ascending & descending SN course of action

Before	0.91	1.35	0.44	0.63	1.19	0.73	0.96	0.29	0.49	0.50
After	0.89	1.33	0.42	0.63	1.16	0.72	0.92	0.30	0.44	0.45

Table 4: Mahalanobis Distance of normal group, after and before optimization by MTS

Before	2.09	3.10	2.63	3.25	1.87	3.22	0.71	1.99	1.12	0.76
After	2.10	3.33	2.66	3.18	1.90	3.24	0.74	2.04	1.12	0.75

Table 5: Mahalanobis Distance of normal group, after and before optimization by MTS

	0-100 $	100-500 $	500-1000 $	Higher than 1000 $
the value of loss	645221646	5627772005	3514601932	11166953456
The number of the customers in this range of losses	1356	2206	517	442
The proportion of loss	0.03	0.27	0.17	0.53
The proportion of number of the customers	0.3	0.49	0.11	0.1

Table 6: The proportion of loss and the proportion of the number of the customers for different ranges of loss

3. Detection of Customers with High-Risk for Insurance company by MTS

Studying the amount of losses inflicted to the organization by the customers, it can be resulted that the customers who inflict losses above 100$to the insurance company, assign an outstanding part of the damage to themselves. And the rest of the groups can be ignored. However this range assigns a wide part to itself. The summary of the results are shown at the table 6.

As what is shown at the table 4 Losses up to 100$ makes only 0.03 of the whole loss and although 0.30 of the customers occupy this rang but it is ignorable comparing the rest of amounts. So the extreme limit (threshold) according the 4 selected factor is calculated in order to increase the discrimination between the customers with a loss higher than 1 million and the customers lesser than this amount. To do so, we practiced the MTS method again using the 600 normal data belonged to the previous step but only with 4 selected factors. The Mahalanobis distance was calculated for them .then the distance for the 200 abnormal data was calculated again.

3.1. Abnormality Scale and the Extreme Limit

One of abilities of the MTS method is that in addition to detection of normal and abnormal groups it can show the amount of abnormality of data which is called abnormality Scale. That means that if illness of a customer is determined, we can assess the amount of his illness according to the customer's Mahalanobis distance from the normal group. When a customer's Mahalanobis distance is high that means the customer has more difference with the customers within the normal groups who are lucrative for the organization. So those customers have higher potential to inflict loss to the company. We used this ability to detect high-risk customers. The extreme (threshold) limit is the Mahalanobis distance for which there is the best discrimination between 2 normal and abnormal groups. Also For insurance data, the extreme limit which shows the best discrimination between the customers with higher and lower than 100$ of loss was calculated. Using the true/false method, Mahalanobis Distances was selected as extreme limit according 2007 data that are useful. Summary of the results are shown at the table 7.

extreme limit	accuracy	percent of high-risk customers
2.36	%87	%20
2.12	%80	%27
2	%70	%31

Table 7: Extreme limit, accuracy in recognition, and percent of high-risk customers for 2007 data

This Mahalanobis distances was calculated using 4 chosen factors and the correlation matrix method of the normal customers of the same year. Now according to this extreme limit, we try to detect the high-risk customers. 500 customers among all the customers who had insured their cars in 2008 were accidentally sampled. Using MTS method and 4 selected factors the Mahalanobis distance was calculated for these customers. According to resulted data, persons whose distance was upper than extreme limit of 2.36 are high-risk by a %82 probability. Summary of the results are shown at the table 8. Although some of customers, who inflicted the same amount of loss, possessed a Mahalanobis distance lesser than that. That means according to this, some of the customers who are highly probable to inflict a high loss to the company was detected.

extreme limit	accuracy	percent of high-risk customers
2.36	%82	%23
2.12	%76	%31
2	%72	%33

Table 8: Validation (extreme limit, accuracy in recognition, percent of high-risk customers for 2008 data)

4. High-Risk customer's recognition by Neural Networks

In this paper, the MTS method has been used for High-Risk customer's recognition.

Neural networks play an important role in recognizing and forecasting for different systems because of high capability in non-linear modeling. Multi layer perceptron is the most famous type of neural networks. Multi layer perceptron with Back Propagation algorithm is the most applicable type of neural networks therefore we use this method for comparison.

The output is a binary variable(y), which is defined as follow:

$$y=\begin{cases} 1 & \text{if the customer's loss is more than 100\$} \\ 0 & \text{if the customer's loss is less than 100\$} \end{cases}$$

Neural network is inferior to MTS because of binary scale. In fact MTS is better that neural network because of the abnormality scale. This algorithm is programmed by MATLAB (R2008a) software. 500 samples used in MTS were used again; with 2 to 1 proportion, so 1000 random samples were selected for training step. The seven input variables were used in first layer. The results were as follows:

Network's type: MLP
Training algorithm: Back Propagation
The number of input neurons: 7 neurons
The number of hidden layer: 3 layers
The number of neuron in each hidden layer:10neurons
The activation function for hidden layers: Tansig
The activation function for output layer: Purelin
Output: 0, 1

According to Network outputs, the number of customers that by network was recognized high-risk is 161 and correct recognition number is 95 so the recognition accuracy is %60. Thus if a customer is known high-risk by the network, the probability will be 60%. The recognition accuracy is improper in comparison to 82% of MTS. High-risk customers behave like outlier data and neural networks are sensitive to them. These customers cannot be eliminated because they are the high-risk customers and are significant for analysis.

Conclusion

The reorganization of the customer's behavior about demand is an essential tool for succeeding in competitive market. In this paper, the MTS was used to this purpose. A case study in automobile insurance was considered. Seven effective factors in accidents were reduced to four. Then, three thresholds were obtained using the MD concept and the high-risk customers were recognized. Devising ways to prevent the accidents and damages will need the recognition of such groups of customers. Then the results were compared to neural networks. The results show that MTS with its abnormality scale has a great capability in recognizing high-risk customer. The results are satisfactory in comparison with neural networks. In fact with using MTS, demand of customers case by case was analyzed and it is an important outcome in analyzing behavior of customers.

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