A fuzzy clustering approach of the customers' demands, which influences the e-banking service quality

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Abstract

The interest rate liberalization have a huge influence for commercial banking management in China, the net interest margin (NIM) is more and more low, but the competition is becoming increasingly fierce, so it is a very necessary and urgent work to strength the management of banks by the key financial innovation. Some researches showed that the e-banking service quality plays an important role during competition among banks as well as the core competence of banks' sustainable development. In order to improve the service quality, the first task is to really master and understand the customer demands, which influence the e-banking service quality. The paper proposed a fuzzy clustering method for customer demands and empirical analysis, and the results showed that all the customer demands can be classified into two clusters according to the maximum value of F-statistics, one of which indicated that the new trend of customer demands in e-commerce environment and have great influence on the decisions of users to use the service of e-banking.

Keywords: e-banking, service quality, customers' demands, fuzzy clustering

1 Introduction

Some researches have shown that the Interest Expense is the most important operating expense for banks (about 85%) in china, and the narrowing of spreads creates a huge challenge for commercial bank management, the interest rate liberalization have also impacted on the profitability of commercial banking [1], so commercial banking have to innovate the payment business and strength the management of banks in order to seek for new sources of profit. In the People's Bank of China (PBC) work conference 2013, which have proposed to promote the reform of interest rate liberalization steadily, to encourage and guide the payment business innovation, and further enhance the level of financial services and management.

With the rapid development of Network Economy and the optimization of electronic payment environment, Electronic banking, i.e., e-banking, as the key channel of business innovation not only can reduce the operation cost, but also can increase the intermediary business income and promote the business innovation, it is more convenient for service the customer, and so on. All variableistics have increasingly become the focus of banks service innovation. According to the "2012 China e-banking research report" of CFCA, which indicated that the e-banking services of china have sustained growth in the past three years, 68% of users use e-banking services instead of the more than half of the counter business, and the replacement rate of some internet-banks are more than 85%. How to improve the e-banking service quality and strengthen the management of banks is an urgent subject in the background of interest rate liberalization in China.

2 Literature review

Many researches have proved that the service quality determines the Customer Satisfaction [2], and the Customer Satisfaction determines Customer Loyalty [3], which directly or indirectly brings in the profit increase. For example, if the customer loyal rises by 5%, the company's net profit will increase by 25%~95% [4]. As mentioned above, the logic can be concluded as: Service Quality → Customer Satisfaction → Customer Loyalty → Profit [5]. Therefore, when evaluating and improving the banking service quality, it is the primary and essential factor to recognize the customer demands, which has been studied by many domestic and foreign professors.

Davis has given a detailed measure, one of the key decisive factors is the Technology Acceptance Model (TAM) [6], and the model is widely synthesized to a set of methods to test users' acceptance psychology among several fields. Karjaluoto et al. have made an investigation on the attitude of users to use e-banking. They held the point of view that users' proficiency to technique is good to use e-banking. Providing customers with fast, convenient and trustworthy service influenced the e-banking development, which is the primary consideration factor for customers to be pushed to accept the e-banking services [7]. Minocha et al. believed that banks should cultivate a positive customer experience for e-Banks and the real atmosphere to attract more users. Lacking trust for the e-business channels is the

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major cause that customer lead to the restriction of extended application of e-bank [8]. Mills et al. had done a research from 92 potential users of internet banking. The results showed that security problem was one of main obstacles that cause e-banking services were refused by users in developing countries [9]. Those security measures that cause inconvenience to the user of the e-banking may result in safety weakness, and the reason is that user lacked of experience. Lee M C. explores and integrates the various advantages of online banking to form a positive factor named perceived benefit with the technology acceptance model (TAM) and theory of planned behavior (TPB) model to propose a theoretical model to explain customers' intention to use online banking. The results indicated that the intention to use online banking is adversely affected mainly by the security/privacy risk, as well as financial risk and is positively affected mainly by perceived benefit, attitude and perceived usefulness [10]. About the factors of perceptive service quality, both Jabnoun and Al-Tamimi thought that the service quality played an important role in protecting market share, and customers believed that stuff's personal professionalism was the biggest factor of service quality [11]. Sadiq Sohail et al. emphasized the importance of customers' perception, and they pointed that the reasonable navigation property, search tools and higher interactivity of e-banking websites have positive influence on perceptive degree of e-banking website-friendly [12]. Li and Worthington also emphasized that the transaction cost, the connection speed and their confidence of e-banking trades have influenced on whether they will use e-banking or not [13]. Chu, Po-Young et al. proposed a research model to examine the relationships between service quality, customer satisfaction, customer trust, and loyalty on Taiwanese e-banking , It was found that e-banks must focus on service quality to increase customer satisfaction and trust to obtain customer loyalty [14]. By studying domestic and foreign research conclusions, Zhang Wei et al. have put forward 10 pieces of assuming dimensions, including appearance, reliability, responsibility, guarantee, empathy, sensibility, technicality, information function, price property and defect degree. They have investigated 2409 users of e-banking. They adopted confirmatory factors to analyse and got 26 questions to support these 10 pieces of assuming dimensions. After testing the relationship between 10 pieces of assuming dimensions and total service quality, they have proved that these 10 pieces of assuming dimensions have positive correlation with service quality and those were factors that influenced service quality [15]. According to the above information, we find that there are many papers of studying e-banking service quality, but it still need to improve on scientific recognition and classification of customers' demands. This paper tries to distinguish customers' demands by fuzzy cluster method, and confirm crucial customers' demands for the e-banking QFD [16], as a system based on customer demands and changing the demands into technical requirements at various stages. Quality Function Deployment (QFD) is now playing a more and more important role in the service design.

3 The fuzzy clustering algorithm

In the fields of science-technology and economy management, which are classified by certain criteria (for example similarity degree or affinity-disaffinity relationship). Because of the boundary of science technology and economy management are ambiguous, it's practical to adopt fuzzy-cluster. It is one of basic methods for making the pattern classification and system modelling [17], it is very simple, direct and easy for the basic thought. It is classified by similarities degrees of each modeling features, that is to say, the similarities will be classifies as a cluster, and the different another [18]. Because fuzzy-cluster can obtain an uncertainty degree of samples that belonging to different classes and present intermediacy of a sample, namely, create an uncertainty description of sample to classification. In this way, it can better present the real world cases so that it will become the main stream of cluster study [19].

The steps of cluster analysis method are described below.

3.1 UNIVERSE VARIABLEIZATION

Assume that the universe U were the clustered case, $U=\{x_1,x_2,...,x_n\}$, where x_i is the ith case, can be indicated as:

$$x_i=\{x_{i1},x_{i2},...,x_{im}\},\ (i=1,2,...,n),$$

where m is the m^{th} variable of each case, so the original data matrix can be obtained as follows:

$$\begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{pmatrix},$$

where x_{nm} is the m^{th} variable of n^{th} case.

3.2 DATA NORMALIZATION [20]

In order to make the different data were compared, it is need to data normalization, the data were compressed to interval [0,1], these methods includes moving-standard deviation normalized, moving-range normalized, logarithmic normalized. In this paper, we use the methods of translation standard difference alternate and translation limit difference alternate.

3.2.1 Moving-standard deviation normalized

$$x'_{ik} = \frac{x_{ik} - \overline{x}_k}{s_k},\ (i = 1,2,...,n; k = 1,2,...,m), \quad (1)$$

where $\overline{x}_k = \frac{1}{n}\sum_{i=1}^{n} x_{ik}$, $s_k = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_{ik} - \overline{x}_k)^2}$.

x'_{ik} can be obtained from the Equation (1), the mean of each case is 0, the standard deviation is 1, and which eliminated the influence of dimension, but the x'_{ik} is not necessarily in the interval [0,1].

3.2.2 Moving-range normalized

$$x''_{ik} = \frac{x'_{ik} - \min\limits_{1\le i\le m}\{x'_{ik}\}}{\max\limits_{1\le i\le m}\{x'_{ik}\} - \min\limits_{1\le i\le m}\{x'_{ik}\}},\ (k = 1,2,...,n) \quad (2)$$

x''_{ik} can be obtained from the Equation (2), it is clearly that $0 \le x''_{ik} \le 1$, the mean of each case is 0, the standard deviation is 1, which have really eliminated the influence of the dimension.

3.3 CALCULATE THE FUZZY SIMILARITY MATRIX

Assume that the universe $U = \{x_1, x_2, ..., x_n\}$, where $x_i = \{x_{i1}, x_{i2}, ..., x_{im}\}$. According to the traditional clustering algorithm to determine the similarity coefficient, the fuzzy similarity matrix can be built, r_{ij} is the similarity degree between x_i and x_j, $r_{ij} = R(x_i, x_j)$. There are several methods to calculate that including the similarity coefficient, distance method and other methods of the traditional clustering algorithm. In this paper, we mainly use the absolute value of the arithmetic subtraction as follows:

$$r_{ij} = 1 - cd(x_i, x_j), \quad (3)$$

where, c is the chosen properly parameter, $0 \le r_{ij} \le 1$, $d(x_i, x_j)$ is the distance between x_i and x_j:

$$d(x_i, x_j) = \sum_{k=1}^{m} \left| x_{ik} - x_{jk} \right|. \quad (4)$$

3.4 CALCULATE THE FUZZY EQUIVALENCE MATRIX

According to the fuzzy similarity matrix R are given to, the fuzzy equivalence matrix R^* which can be obtained by transformation use the transitive closure method. The transitive closure of R can be calculate by square arithmetic as follows:

$$t(R) = R^*. \quad (5)$$

The $t(R)$ is the fuzzy equivalence matrix, which meet the reflexivity, symmetry and transitivity.

3.5 CLUSTERING

For $t(R)$, which cutting matrix can be calculated by different threshold λ, Through analysis the similarity degree of cutting matrix elements, the factors of each customer demand will be carried out clustering.

Assume that the $\tilde{R} = (r_{ij})_{m\times n}$ is fuzzy matrix, for any $\lambda \in [0,1]$, the $\tilde{R}_\lambda = (r_{ij}^{(\lambda)})_{m\times n}$ indicates the λ - cutting matrix of $\tilde{R} = (r_{ij})_{m\times n}$, where,

$$r_{ij}^{(\lambda)} = \begin{cases} 1, & r_{ij} \ge \lambda \\ 0, & r_{ij} < \lambda \end{cases}.$$

3.6. DETERMINE THE OPTIMAL THRESHOLD λ

During fuzzy clustering analysis, we can get different classification with different threshold, $\lambda \in [0,1]$, When the threshold is decreased gradually from big to small, classification is changed from thin to thick, so it forms a dynamic clustering analysis shown in Figure 1. Through the cluster analysis chart, according to the actual problem, select the best threshold, it can get the sort of case classification and realize the identifying and analysis for the customer demand of e-banking service quality. In this paper which use F- Statistic to determine the threshold λ.

Assume that the universe $U = \{x_1, x_2, ..., x_n\}$ is the case set, each case have m variables, $x_i = \{x_{i1}, x_{i2}, ..., x_{im}\}$, $(i = 1,2,...,n)$, so the original data matrix can be expressed as follows:

TABLE 1 The original data matrix

	V_1	V_2	...	V_k	...	V_m
C_1	x_{11}	x_{12}	...	x_{1k}	...	x_{1m}
C_2	x_{21}	x_{22}	...	x_{2k}	...	x_{2m}
...	...	...	...	...	...	...
C_i	x_{i1}	x_{i2}	...	x_{ik}	...	x_{im}
...	...	...	...	...	...	...
C_n	x_{n1}	x_{n2}	...	x_{nk}	...	x_{nm}
$\overline{x}$	$\overline{x}_1$	$\overline{x}_2$	...	$\overline{x}_k$	...	$\overline{x}_m$

* C_n indicates the n^{th} case, V_m indicates the m^{th} variable.

$$\overline{x}_k = \frac{1}{n}\sum_{i=1}^{n} x_{ik},\ (k = 1,2,...,m), \quad (6)$$

where, $\overline{x}$ was called the centre vector of case.

Assume that r is the number of clusters, which corresponds to λ, the n_j is the j^{th} number of case which can be indicated as $x_1^{(j)}, x_2^{(j)}, ..., x_{n_j}^{(j)}$, the j^{th} clustering center can be indicated as $\overline{x}^{(j)} = (\overline{x}_1^{(j)}, \overline{x}_{12}^{(j)}, \cdots, \overline{x}_m^{(j)})$, where $\overline{x}_k^{(j)}$ is the mean of the k^{th} variable,

$$\overline{x}_k^{(j)} = \frac{1}{n_j}\sum_{i=1}^{n_j} x_{ik}^{(j)}, \ (k = 1, 2, ..., m). \tag{7}$$

F-Statistic can be calculated as follows,

$$F = \frac{\sum_{j=1}^{r} \frac{n_j \left\| \overline{x}^{(j)} - \overline{x} \right\|}{r-1}}{\sum_{j=1}^{r}\sum_{i=1}^{n_j} \frac{\left\| x_i^{(j)} - \overline{x}^{(j)} \right\|}{n-r}}, \tag{8}$$

$$\left\| \overline{x}^{(j)} - \overline{x} \right\| = \sqrt{\sum_{k=1}^{m} (\overline{x}_k^{(j)} - \overline{x}_k)^2}. \tag{9}$$

It is the distance between $\overline{x}^{(j)}$ and $\overline{x}$, $\left\| x_i^{(j)} - \overline{x}^{(j)} \right\|$ is the distance between the i^{th} case and the centre in j^{th} cluster. F-Statistic is a F-distribution which complies with $r-1$, $n-r$ degrees of freedom. Its molecular indicated that the distance between the different classes, its denominator indicated that the distance between the different cases. That is to say, the value of F-Statistic is bigger, the diversity between the different classes is bigger, and the classes are better.

4 Empirical research

4.1 QUESTIONNAIRE-INVESTIGATION

In order to analyse scientifically the customer demands which influence the e-banking service quality, we investigated 10 commercial banking which include 7000 customers. The investigation cases include students, the workers, senior director, individual operators, retired workers. We use the method of questionnaire-investigation to assess the attention degree of relevant indicators. The investigation questionnaire is mainly focus on 11 dimensional to set which including the appearance x_1, the information function x_2, response x_3, guarantee x_4, price x_5, sensitivity x_6, technical x_7, convenience x_8, empathy x_9, defect degree x_{10}, safety x_{11}, the questionnaire use the answer of yes or no as the choice of customers whether focus on some question, which is convenient for the customers to choose.

The questionnaires were sent by email. Those persons who take part in the questionnaires were provided and contacted by Shanghai Quality Association, because they are familiar with the situation which involved in the questionnaire. A total of 7000 questionnaires were sent to the users of 10 banks (B_1, B_2,…, B_{10}). A total of 5000 questionnaires were responded, in which, there were a total of 4698 valid questionnaires, the response rate was 71.43%, and the effective rate was 67.1%. The relevant problems and measures as shown in Table 2.

TABLE 2 The questionnaire of customer demands which influence the e-banking service quality

	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	B_{10}
x_1	274	250	191	245	290	465	257	452	157	323
x_2	322	285	431	230	309	156	325	363	269	404
x_3	156	346	287	240	499	221	429	354	407	232
x_4	409	340	559	277	384	174	397	448	304	516
x_5	287	305	474	262	325	159	356	379	278	437
x_6	252	448	496	304	404	197	375	414	404	514
x_7	304	278	214	266	345	495	294	475	194	351
x_8	295	443	212	307	259	312	405	220	171	335
x_9	166	393	311	276	594	231	393	351	421	242
x_{10}	233	297	401	317	280	268	189	306	332	272
x_{11}	309	459	221	341	281	339	410	241	174	360

4.2 DATA NORMALIZATION

From the Equation (1), the Table 1 was transformed using the method of moving-standard deviation normalized, we can obtained the Table 3 as follows:

TABLE 3 Translation standard difference alternate

	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	B_{10}
x_1	0.01	-1.33	-1.17	-0.96	-0.68	1.62	-1.22	1.06	-1.26	-0.4
x_2	0.68	-0.86	0.65	-1.39	-0.5	-1	-0.31	-0.01	-0.14	0.43
x_3	-1.64	-0.05	-0.44	-1.1	1.33	-0.45	1.08	-0.12	1.24	-1.33
x_4	1.9	-0.13	1.62	-0.05	0.22	-0.85	0.65	1.01	0.21	1.57
x_5	0.19	-0.59	0.98	-0.48	-0.34	-0.98	0.1	0.18	-0.05	0.76
x_6	-0.3	1.31	1.14	0.72	0.41	-0.66	0.36	0.6	1.21	1.55
x_7	0.43	-0.95	-0.99	-0.36	-0.15	1.87	-0.72	1.33	-0.89	-0.12
x_8	0.3	1.25	-1.01	0.81	-0.98	0.32	0.76	-1.73	-1.12	-0.28
x_9	-1.5	0.58	-0.26	-0.08	2.24	-0.37	0.6	-0.16	1.38	-1.23
x_{10}	-0.57	-0.7	0.42	1.1	-0.78	-0.05	-2.13	-0.7	0.49	-0.92
x_{11}	0.5	1.46	-0.94	1.78	-0.77	0.55	0.83	-1.48	-1.09	-0.02

From the Equation (2), the Table 2 was transformed using the method of moving-range normalized, we can obtained the Table 4 as follows:

TABLE 4 Translation limit difference alternate

	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	B_{10}
x_1	0.47	0.00	0.00	0.14	0.09	0.91	0.28	0.91	0.00	0.32
x_2	0.66	0.17	0.65	0.00	0.15	0.00	0.57	0.56	0.42	0.61
x_3	0.00	0.46	0.26	0.09	0.72	0.19	1.00	0.53	0.95	0.00
x_4	1.00	0.43	1.00	0.42	0.37	0.05	0.87	0.89	0.56	1.00
x_5	0.52	0.26	0.77	0.29	0.20	0.01	0.70	0.62	0.46	0.72
x_6	0.38	0.95	0.83	0.67	0.43	0.12	0.78	0.76	0.94	0.99
x_7	0.59	0.13	0.06	0.32	0.26	1.00	0.44	1.00	0.14	0.42
x_8	0.55	0.92	0.06	0.69	0.00	0.46	0.90	0.00	0.05	0.36
x_9	0.04	0.68	0.33	0.41	1.00	0.22	0.85	0.51	1.00	0.04
x_{10}	0.30	0.22	0.57	0.78	0.06	0.33	0.00	0.34	0.66	0.14
x_{11}	0.60	1.00	0.08	1.00	0.07	0.54	0.92	0.08	0.06	0.45

4.3 BUILT THE FUZZY SIMILARITY MATRIX

From the Equation (3), the values in Table 3 were calculated using Matlab software, the fuzzy similar matrix can be obtained as follows: $R(r_{\alpha\beta})_{11\times11}$.

$$R=\begin{bmatrix}
1.0000 & & & & & & & & & & \\
0.6545 & 1.0000 & & & & & & & & & \\
0.5056 & 0.6215 & 1.0000 & & & & & & & & \\
0.4773 & 0.7184 & 0.5525 & 1.0000 & & & & & & & \\
0.6198 & 0.8962 & 0.6265 & 0.7946 & 1.0000 & & & & & & \\
0.4226 & 0.6389 & 0.6169 & 0.7710 & 0.7427 & 1.0000 & & & & & \\
0.8760 & 0.6835 & 0.5126 & 05656 & 0.6754 & 0.4871 & 1.0000 & & & & \\
0.6212 & 0.5731 & 0.5312 & 0.4995 & 0.5950 & 0.5837 & 0.6398 & 1.0000 & & & \\
0.4438 & 0.5578 & 0.8783 & 0.5503 & 0.6024 & 0.6630 & 0.4886 & 0.5625 & 1.0000 & & \\
0.6084 & 0.6815 & 0.6052 & 0.5332 & 0.6831 & 0.5924 & 0.5896 & 0.6191 & 0.6146 & 1.0000 & \\
0.5857 & 0.5575 & 0.4911 & 0.4838 & 0.5683 & 0.5618 & 0.6260 & 0.9189 & 0.5183 & 0.5923 & 1.0000
\end{bmatrix}$$

For the fuzzy similarity matrix, we can carry out the calculation of transitive closure by square arithmetic as follows:

$$R^2 \to R^4 : R^4 \text{ i.e., } t(R) = R^4 = R^*.$$

4.4 CLUSTERING

R is a symmetric matrix, so only a lower triangular matrix was given to:

$$R^*=\begin{bmatrix}
1.0000 & & & & & & & & & & \\
0.6835 & 1.0000 & & & & & & & & & \\
0.6630 & 0.6630 & 1.0000 & & & & & & & & \\
0.6835 & 0.7946 & 0.6630 & 1.0000 & & & & & & & \\
0.6835 & 0.8962 & 0.6630 & 0.7946 & 1.0000 & & & & & & \\
0.6835 & 0.7710 & 0.6630 & 0.7710 & 0.7710 & 1.0000 & & & & & \\
0.8760 & 0.6835 & 0.6630 & 0.6835 & 0.6835 & 0.6835 & 1.0000 & & & & \\
0.6398 & 0.6398 & 0.6398 & 0.6398 & 0.6398 & 0.6398 & 0.6398 & 1.0000 & & & \\
0.6630 & 0.6630 & 0.8783 & 0.6630 & 0.6630 & 0.6630 & 0.6630 & 0.6398 & 1.0000 & & \\
0.6831 & 0.6831 & 0.6630 & 0.6831 & 0.6831 & 0.6831 & 0.6831 & 0.6398 & 0.6630 & 1.0000 & \\
0.6398 & 0.6398 & 0.6398 & 0.6398 & 0.6398 & 0.6398 & 0.6398 & 0.9189 & 0.6398 & 0.6398 & 1.0000
\end{bmatrix}$$

We denote by $\lambda = 1$, obviously, it can be divided into 11 clusters, i.e. $\{x_1\}$, $\{x_2\}$, $\{x_3\}$, $\{x_4\}$, $\{x_5\}$, $\{x_6\}$, $\{x_7\}$, $\{x_8\}$, $\{x_9\}$, $\{x_{10}\}$, $\{x_{11}\}$.

We denote by $\lambda = 0.9189$ then

$$R^*_{0.919}=\begin{bmatrix}
1 & & & & & & & & & & \\
 & 1 & & & & & & & & & \\
 & & 1 & & & & & & & & \\
 & & & 1 & & & & & & & \\
 & & & & 1 & & & & & & \\
 & & & & & 1 & & & & & \\
 & & & & & & 1 & & & & 1 \\
 & & & & & & & 1 & & & \\
 & & & & & & & & 1 & & \\
 & & & & & & 1 & & & & 1
\end{bmatrix}$$

For x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, the similarity degree is 1 when adopt the confidence level of 0.9189, so the above cases can be divided into 10 clusters, i.e. $\{x_1\}$, $\{x_2\}$, $\{x_3\}$, $\{x_4\}$, $\{x_5\}$, $\{x_6\}$, $\{x_7\}$, $\{x_8\}$, $\{x_9\}$, $\{x_{10}\}$, $\{x_{11}\}$.

When the confidence level λ was gradually reduced, we can obtain different clusters with different λ.

We denote by $\lambda = 0.8962$ then the above cases can be divided into 9 clusters, i.e. $\{x_1\}$, $\{x_2, x_5\}$, $\{x_3\}$, $\{x_4\}$, $\{x_6\}$, $\{x_7\}$, $\{x_8, x_{11}\}$, $\{x_9\}$, $\{x_{10}\}$.

We denote by $\lambda = 0.8783$ then the above cases can be divided into 8 clusters, i.e. $\{x_1\}$, $\{x_2, x_5\}$, $\{x_3, x_9\}$, $\{x_4\}$, $\{x_6\}$, $\{x_7\}$, $\{x_8, x_{11}\}$, $\{x_{10}\}$.

We denote by $\lambda = 0.8760$ then the above cases can be divided into 7 clusters, i.e. $\{x_1, x_7\}$, $\{x_2, x_5\}$, $\{x_3, x_9\}$, $\{x_4\}$, $\{x_6\}$, $\{x_8, x_{11}\}$, $\{x_{10}\}$.

We denote by $\lambda = 0.7946$ then the above cases can be divided into 6 clusters, i.e. $\{x_1, x_7\}$, $\{x_2, x_4, x_5\}$, $\{x_3, x_9\}$, $\{x_6\}$, $\{x_8, x_{11}\}$, $\{x_{10}\}$.

We denote by $\lambda = 0.7710$ then the above cases can be divided into 5 clusters, i.e. $\{x_1, x_7\}$, $\{x_2, x_4, x_5, x_6\}$, $\{x_3, x_9\}$, $\{x_8, x_{11}\}$, $\{x_{10}\}$.

We denote by $\lambda = 0.6835$ then the above cases can be divided into 4 clusters, i.e. $\{x_1, x_2, x_4, x_5, x_6, x_7\}$, $\{x_3, x_9\}$, $\{x_8, x_{11}\}$, $\{x_{10}\}$.

We denote by $\lambda = 0.6831$ then the above cases can be divided into 3 clusters, i.e. $\{x_1, x_2, x_4, x_5, x_6, x_7, x_{10}\}$, $\{x_3, x_9\}$, $\{x_8, x_{11}\}$.

We denote by $\lambda = 0.6630$ then the above cases can be divided into 2 clusters, i.e. $\{x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_9, x_{10}\}$, $\{x_8, x_{11}\}$.

We denote by $\lambda = 0.6398$ then the above cases can be divided into 1 cluster, i.e. $\{x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}\}$.

Consequently, we can obtain the cluster diagram as follows:

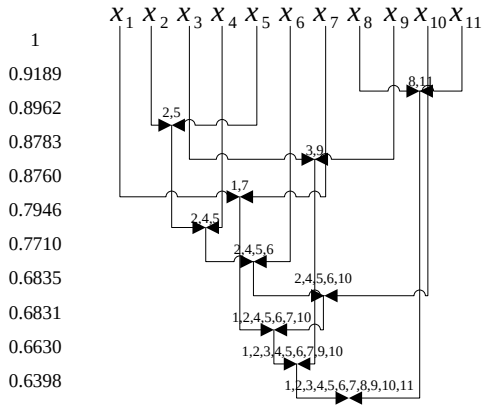

FIGURE 1 Cluster diagram

4.5. DETERMINE THE OPTIMAL THRESHOLD

From the Equations (6-9), we can obtain the value of F-Statistic by calculated the original data matrix, which the maximum value of *F* is the optimal classification.

TABLE 5 The λ value corresponding to the F-statistics

λ	**1**	**0.92**	**0.9**	**0.88**	**0.88**	**0.79**	**0.77**	**0.68**	**0.68**	**0.66**	**0.64**
r	11	10	9	8	7	6	5	4	3	2	1
F	0	0.07	0.15	0.26	0.4	0.54	0.83	1.03	1.5	2.12	-

From Table 5, we can make a conclusion that all the customers' demands of e-banking can be divided into 11 classifications based on the similarity parameter of 10 banks, questionnaire-investigation and the optimal classification are two classifications.

5 Conclusions

By the way of fuzzy clustering to analyse the 11 kinds of customer demands which influence the e-banking service

quality, which included the appearance, the information function, response, guarantee, price, sensitivity, technical, reliability, empathy, defect degree, safety. Not only classifies the attention degree of relevant indicators which have similarly features into one class, but also distinguishes the optimal classification with F-Statistic. The results of classification fairly showed that the emphases of attention degree are empathy and safety, and the customer demands have an important role to influence the e-banking service quality. From the literature review, we have known that the improved service quality can indirectly increase the profit of commercial banking, so it should be an important input factor for QFD (Quality Function Deployment), and the e-banking should pay attention to its unique advantages and get the trust of customers.

Fuzzy clustering method is a developing analysis approach, and it has a close relationship with computer software. It is practical in technique to use fuzzy mathematical principles in classification and choosing of the customer demands which influence the e-banking service quality. But there will constantly appear some new and uncertain factors which influences e-banking service quality with the development of science and economy, which will influence the classification results. Therefore, how to make further choice and reduce deviation is valuable for us to study.

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