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Research on Business Satisfaction of Beijing Mobile Customers Based on Comprehensive Weight Evaluation Model

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Abstract: *With the development of the information age, each mobile operator pays more and more attention to customers' network experience. In order to investigate the influencing factors of customers' voice service and Internet service experience, this paper firstly preprocesses the data by using spss, and secondly determines whether there is a linear relationship between the independent variable and the dependent variable, and analyzes the correlation by using Pearson's correlation coefficient. After that, we combined the principal component analysis method to reduce the dimensionality of the above variable indicators, and screened out the important influence indicators. Finally, using hierarchical analysis method (AHP), entropy weight method and decision power coefficient to carry out comprehensive weight analysis on the weight of each indicator, so as to summarize the main factors affecting customers' satisfaction with voice service and Internet service.*

Keywords: *Customer satisfaction, Pearson coefficient, PCA, AHP, Entropy weighting*

1. Introduction

With the continuous development of the information technology era, various mobile operators nowadays pay more and more attention to customers' network experience. For example, China Mobile Communications Group Beijing Company has statistically organized the factors affecting customers' voice service and Internet service experience, hoping to analyze the main factors affecting customers' satisfaction with their voice service and Internet service experience, so as to improve customers' satisfaction and Internet experience.

In order to investigate the factors affecting the satisfaction of customers' voice service and Internet service experience, we found that a large number of scholars have conducted research and discussion on the investigation of the factors affecting the satisfaction by reviewing the literature, for example, Xu Xiaojin conducted descriptive statistics, reliability analysis, and correlation analysis of the recovered valid questionnaires by using the SPSS software, and finally determined indicators[1];Miao Yingchun and Li Rui constructed a satisfaction evaluation model of health service accessibility in community health centers based on principal component analysis[2]; Lu Jing and Deng Yingli established a satisfaction evaluation model based on the satisfaction survey data using AHP and fuzzy comprehensive evaluation method[3]; Wang Na and Li Jie established the weights of the indicators through the questionnaire research using AHP and entropy weighting[4]; and Geng Yuming used the comprehensive fuzzy hierarchical analysis method to establish a satisfaction model of Geng Yuming used the comprehensive fuzzy hierarchical analysis method to establish a model for evaluating the impact of digital RMB on mobile payment user satisfaction[5]; Cai Zhixin started from the overall status of the communication industry and the reality of customer satisfaction in Company Limited Nanchang Branch, and utilized the Delphi method to carry out the research of Nanchang mobile customer satisfaction measurement[6].

Therefore, this paper utilizes the hierarchical analysis method (AHP), entropy weight method, and decision power coefficient to analyze the weight of each index, so as to summarize the main factors affecting the customer's satisfaction with voice service and Internet service.

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2. Modeling and solving

2.1 Data pre-processing

In the original dataset, there may be a large amount of extreme data, so the data needs to be preprocessed. The data processing in this thesis includes: elimination of outliers, one-hot coding, and normalization of data.

Since there are a certain amount of extreme values and outliers in the data, and they will affect the evaluation effect to a greater extent; therefore, this paper first carries out data preprocessing:

Step1: For the found data, first screen the data anomalization caused by malicious scoring due to customers' subjective factors, and delete the extreme outliers, so as to avoid the influence of extreme data on the subsequent modeling results.

Step2: There are some fixed-class data in the data, and the fixed-class data are quantized using One-hot coding (One-hot).

Step3: Data normalization processing.

$$x = \frac{x - V_{min}}{V_{max} - V_{min}} \tag{1}$$

Step4: Determine whether there is a linear relationship between each variable in the data and the dependent variable of interest.

2.2 Using Pearson's correlation coefficient to find correlation

In this paper, the degree of influence of each factor on customer scoring as a response variable and does not have the degree of rank correlation, it is more suitable to utilize the Pearson correlation coefficient to measure the linear correlation between the variables, so as to screen out the influencing factors. Therefore Pearson correlation coefficient is chosen for customer scoring feature selection[7].

1) Pearson correlation coefficient analysis is carried out using MATLAB to calculate the correlation between each independent variable and the four dependent variables in the database, namely, overall satisfaction of voice calls, network coverage and signal strength, clarity of voice calls, and stability of voice calls.

It is generally considered:

$|r| \geq 0.8$, the two variables can be considered highly correlated; $0.5 \leq |r| < 0.8$, the two variables can be considered moderately correlated; $0.3 \leq |r| < 0.5$, the two variables can be considered lowly correlated; $|r| < 0.3$, the two variables can be considered basically uncorrelated.

The relevant indicators and their significance are shown in Table 1.

Table 1: Relevant indicators and their significance in the database

Index	Significance of indicators	Index	Significance of indicators
X1	Overall satisfaction with voice calls	X7	Overall Satisfaction with Mobile Internet
X2	Network coverage and signal strength	X8	Network coverage and signal strength
X3	Clarity of voice calls	X9	Mobile internet speed
X4	Voice call stability	X10	Mobile internet stability
X5	Experienced network problems	X11	Number of poor quality internet accesses
X6	Cell phone signal	X12	Cumulative consumption for the year

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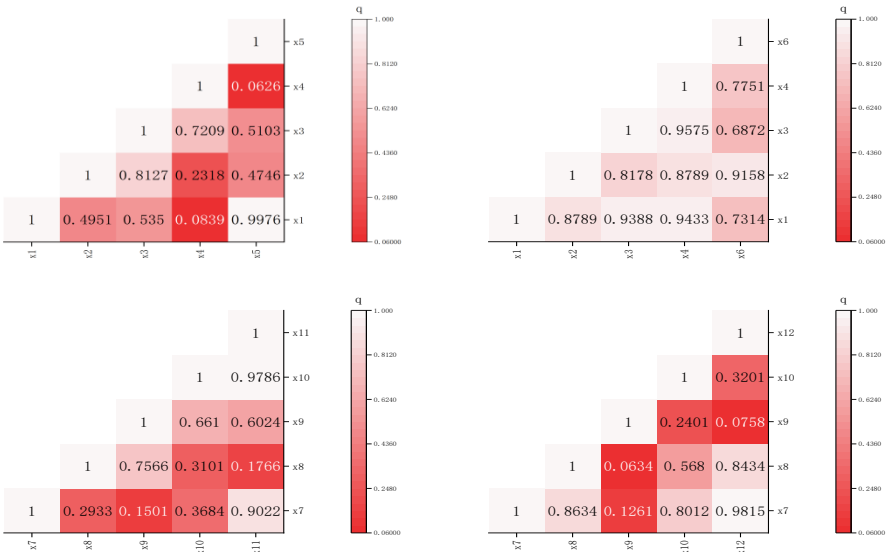

Figure 1: Thermal maps of correlation between independent and dependent variables are obtained using Pearson correlation coefficient

According to the figure 1, it can be proved that whether there is network problem has the greatest correlation with the overall satisfaction of voice call, which is 0.9976; whether there is no signal of mobile phone and network coverage has the greatest correlation with signal strength, which is 0.9158.

Similarly, the correlation between other variables and the overall satisfaction of voice call, network coverage and signal strength, voice call clarity and voice call stability can be obtained, and the variable with strong correlation can be obtained, while the correlation with the above four dependent variables is very small (<0.3) variable discard.

Therefore, the eigenvalue variable with the greatest correlation with the four dependent variables can be obtained by using the Pearson correlation coefficient.

2) Pearson correlation coefficient analysis was carried out with MATLAB to calculate the correlation between each independent variable and the four dependent variables in the database: overall satisfaction with mobile Internet, network coverage and signal strength, mobile Internet speed and mobile Internet stability.

As can be seen from the figure above, the number of poor Internet access quality has the greatest correlation with the stability of mobile Internet access, which is 0.9786, and the cumulative consumption this year has the greatest correlation with the overall satisfaction of mobile Internet access, which is 0.9815.

Similarly, the correlation between other variables and the overall satisfaction of mobile Internet access, network coverage and signal strength, mobile Internet access speed, and mobile Internet access stability can be obtained, and the variables with strong correlation can be obtained, while the correlation with the above four dependent variables is very small (<0.3) variable discard.

Therefore, the eigenvalue variable with the greatest correlation with the four dependent variables can be obtained by using the Pearson correlation coefficient.

2.3 Using principal component analysis to reduce the dimensionality

1) The concept of PCA

Principal component analysis (PCA) can transform the interrelated index variables into uncorrelated index variables. The index variables with more numbers are transformed into the index variables with fewer numbers; Several new variables with large variance can synthesize the main information contained in multiple variables. Therefore, the main influencing factors can be identified[8].

Taking mobile phone Internet stability as an example, the principal component dimension reduction process is carried out. Each index and its symbol are shown in Table 2:

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Table 2: Index table after dimensionality reduction

Index	Significance of indicators	Index	Significance of indicators
X_1	Entertainment software	X_4	The number of times the Internet quality is poor
X_2	Game software	X_5	Off-grid times
X_3	Life software	X_6	The number of times the Wechat quality is poor

2) The calculation steps of principal component analysis are as follows:

(a) Calculate the correlation matrix

(b) Calculate eigenvalues and eigenvectors

$$r_{ij} = \frac{\sum_{k-1}^{n}(x_{ki} - \overline{x_i})(x_{kj} - \overline{x_j})}{\sqrt{\sum_{k-1}^{n}(x_{ki} - \overline{x_i})^2 \sum(x_{kj} - \overline{x_j})^2}} \tag{2}$$

Principal component $\mathbf{z_i}$ Contribution rate:

$$r_i = \sum_{k=1}^{p} \gamma_k \ (i = 1,2,3,\ldots,p) \tag{3}$$

Cumulative contribution rate:

$$\sum_{K}^{M} \Gamma_K \Big/ \sum_{K}^{P} \Gamma_K \tag{4}$$

The results after calculation are shown in Table 3:

Table 3: Principal component eigenvalue, cumulative contribution value

Principal component	Eigenvalue	Variance contribution rate (%)	Cumulative contribution rate (%)
X_1	1.8080	0.3013	0.3013
X_2	1.0382	0.1730	0.4744
X_3	0.9902	0.1650	0.6394
X_4	0.9656	0.1609	0.8003
X_5	0.6820	0.1137	0.9140
X_6	0.5160	0.0860	1.0000

(3) Calculate the principal component load, and then further calculate the principal component score:

$$z = \begin{bmatrix} z_{11} & \cdots & z_{1m} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{nm} \end{bmatrix} \tag{5}$$

The contribution rate of entertainment software, game software, life software and poor Internet quality reached 80.03%. Therefore, this paper uses these 4 influencing factors as the main components instead of the original 6 influencing factors.

A total of 27 major impact indicators were selected by principal component analysis for primary indicators, as shown in the figure 2 below:

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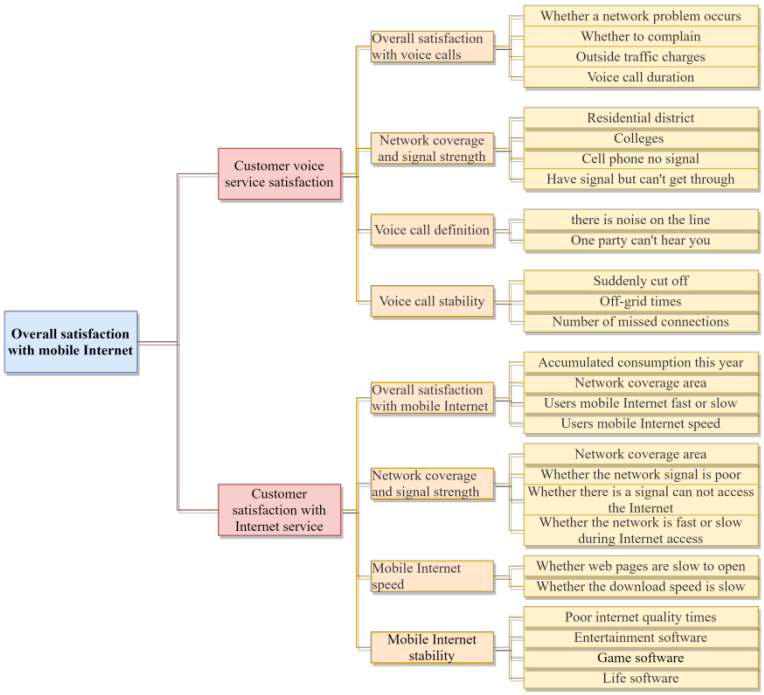

Figure 2: Key indicators selected by principal component analysis

2.4 Determine the weight of each indicator

In this paper, a subjective weighting method, analytic hierarchy Process (AHP), two objective weighting methods, entropy method and decision power coefficient are comprehensively selected for evaluation, and then the average value of their weights is calculated to obtain the comprehensive weight.

Step1: Analytic Hierarchy Process (AHP)

Analytic hierarchy Process (AHP), referred to as a decision-making method, breaks down the elements related to decision-making into different levels such as goals, criteria, and schemes, and then carries out qualitative and quantitative analysis on this basis. When the analytic hierarchy process is applied to solve the problem, the problem should be organized and stratified first, and a hierarchical structure model should be constructed[9].

Take the influence degree of each factor in the database on the customer's voice service satisfaction score as an example to show the operation process of analytic hierarchy process through figure 3.

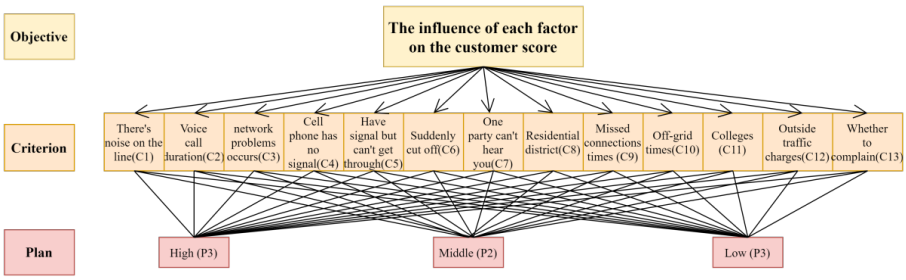

Figure 3: Hierarchical analysis hierarchy diagram

Consistency test of judgment matrix:

(1)Calculate the consistency index CI

(2)Finds the corresponding average random consistency index RI.

(3)Calculate the consistency ratio CR

When CR<0.1, it is considered that the consistency of the judgment matrix is acceptable, otherwise the judgment matrix should be appropriately modified.

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The calculation results are shown in Table 4 and Table 5.

Table 4: AHP hierarchical analysis results

Item	Eigenvector	Weighted value(%)
C1	0.307	0.997
C2	0.231	0.752
C3	0.153	0.496
C4	0.26	0.844
C5	0.436	1.418
C6	1.22	3.966
C7	0.61	1.983
C8	1.456	4.732
C9	1.627	5.287
C10	1.687	5.482
C11	3.273	10.636
C12	6.318	20.53
C13	13.196	42.877

Table 5: Consistency test results

Maximum characteristic root	CR value	Consistency test result
14.758	0.093	Pass

Step 2: Entropy weight method

1) Establishment of entropy weight model

(a)The basic forward matrix is as follows:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{pmatrix} \quad (6)$$

(b)Calculate probability matrix and information entropy

$$P_{ij} = \frac{Z_{Ij}}{\sum_{I=1}^{N} Z_{Ij}} \quad (7)$$

$$E_J = -\frac{1}{Ln\,N}\sum_{I=1}^{N} P_{Ij}\,Ln(P_{Ij})\ (J = 1,2,\cdots,m) \quad (8)$$

2) Calculation of entropy weight method

$$W_J = {D_J}\Big/{\sum_{J=1}^{M} D_J}\ (J = 1,2,\cdots,m) \quad (9)$$

3. Results

Combined with decision weight coefficient method and entropy weight method, the weights obtained by the three methods are treated with the mean value. The weight values of the main factors affecting customer satisfaction with voice service and Internet service are solved as shown in figure 4:

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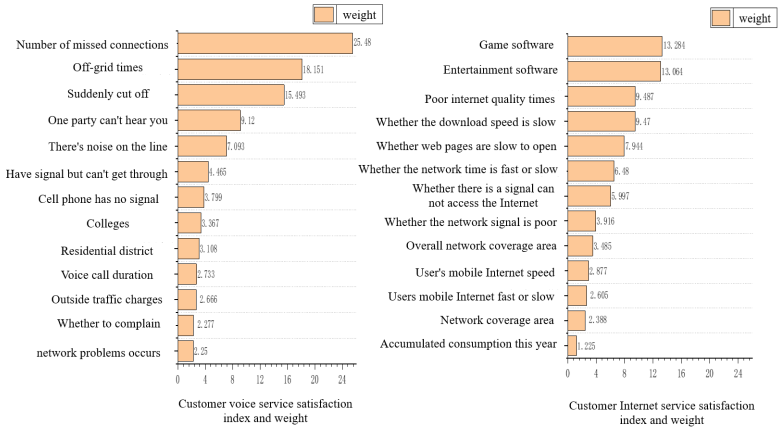

Figure 4: Customer voice service satisfaction and customer Internet service satisfaction indicators and comprehensive weight bar chart

4. Conclusions

With the development of the information age, mobile operators pay more and more attention to customers' network experience. In order to study the main factors affecting customer satisfaction with voice service and Internet service experience, this paper uses AHP, entropy weight method and decision power coefficient to conduct comprehensive weight analysis of each index. This paper summarizes the main factors affecting the customer satisfaction of voice service and Internet service of China Mobile Communications Group Beijing Company, and gives the quantitative analysis and results of the influence of each factor on the customer rating. The hope is that this will help the company improve customer voice satisfaction and Internet experience. After analysis and verification, the model in this paper is reasonable and has certain practical significance. In the context of the digital economy era, major operators should establish a comprehensive customer experience evaluation system, and jointly promote the high-quality sustainable development of mobile networks.

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