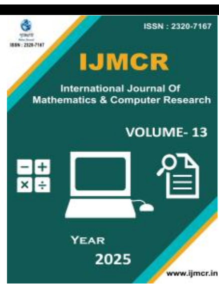
International Journal of Mathematics and Computer Research

ISSN: 2320-7167

Volume 13 Issue 05 May 2025, Page no. – 5247-5252

Index Copernicus ICV: 57.55, Impact Factor: 8.615

DOI: 10.47191/ijmcr/v13i5.16



Identification of Factors Influencing the Preferences of College Students in Choosing SIM Cards Using the Orthogonal Factor Model

Albert Gabriel Lumban Gaol[1], Moch. Abdul Mukid[2], Bagus Arya Saputra[3], Masithoh Yessi Rochayani[4]

[1,2,4]Department of Statistics, Faculty of Science and Mathematics, Diponegoro University, Jalan Prof. Jacob Rais, Tembalang Semarang – 50275, Indonesia

[3]Department of Mathematics, Faculty of Science and Mathematics, Diponegoro University, Jalan Prof. Jacob Rais, Tembalang Semarang – 50275, Indonesia

ARTICLE INFO

Published Online:
28 May 2025

Corresponding Author:
Moch. Abdul Mukid

ABSTRACT

A Subscriber Identity Module (SIM) card is a key component in mobile telecommunication systems that stores identity information and enables access to mobile networks. Students' choice of SIM card is important given their need for efficient communication, fast and stable internet access, and other additional services. This study aims to identify factors that influence the preferences in choosing a SIM card using the orthogonal factor model. This model is applied to simplify a large number of variables into several main factors that are not correlated with each other, making interpretation easier. Data was collected through a questionnaire involving 257 respondents and analyzed using the principal component factoring (PCF) technique for parameter estimation. PCF was chosen due to its ability to extract principal components that represent the largest variance of the data, so that the resulting factors are more accurate in describing student preferences. The study results indicate that six key factors affect students' preferences when selecting a SIM card: price, service, network quality, promotional offers, extra features, and bonuses. Understanding these factors, service providers can design more effective marketing strategies to attract and retain student customers.

KEYWORDS: Preferences; SIM Cards; College Students; Orthogonal Factor Model; Principal Component Factoring

I. INTRODUCTION

The development of information and communication technology has had a major impact on our daily lives, including the way we communicate. A Subscriber Identity Module (SIM) card is an essential element of a mobile device that allows users to connect to a telecommunications network. In addition to functioning as a communication tool, SIM cards also provide various services, such as voice calls, text messages, and internet access, which are very important in today's digital era [1].

Students, as one of the largest user segments, have special needs for SIM cards. These needs include efficient communication with family and friends, fast and stable access to the internet for academic purposes, and the use of additional services such as social media and educational applications. With the variety of activities carried out by students, the SIM card used must be able to meet these various needs [2].

Several important factors that can influence the choice of student SIM cards include price, service quality, internet speed, and promotions and bonuses offered by service providers. For students with a limited budget, affordability is one of the most important considerations. Service quality, such as network stability and customer support, is also very important to ensure a satisfactory user experience [3]. In addition, high and stable internet speed is also needed for various online activities, such as accessing lecture materials, attending online lectures, and conducting research [4]. Promotions and bonuses from service providers can also attract students. Cheap data packages, telephone bonuses, and short message services (SMS) can be one of the determining factors in choosing a SIM card, because they can help students save on communication costs [5]. To better understand student preferences in choosing a SIM card, an analysis is needed that can extract assessment indicators so that they can produce new factors that are not correlated with each other. One of the statistical methods that can be used is orthogonal factor analysis, which is more often referred to as factor analysis. Factor analysis is a statistical analysis method that can extract assessment indicators to produce new factors that are not correlated with each other. Factor analysis is used by researchers to find factors that cannot be observed directly, such as service quality and human intelligence. Spearman first used factor analysis in psychology when he found that there seemed to be no positive correlation between school children's achievements in various subjects [6]. This led him to postulate that general basic abilities (also known as g theory) shape human intelligence. Raymond Cattell then expanded Spearman's ideas and formulated his 16 personality factors to explain human intelligence. In addition to being used in psychology, factor analysis is also widely used in various industries and fields of science, one of which is marketing.

According to Santoso, factor analysis is the study of the interdependence of several variables that were initially independent, so that one or more sets of variables that are smaller than the original number of variables can be created [7]. This set of variables is called a factor, where the factor still reflects the original variable. In factor analysis, a large number of variables are grouped into several factors that have almost the same properties and characteristics to create a model that facilitates processing. The main purpose of factor analysis is to describe the variance of covariance between variables that can be divided into several basic characteristics, but the magnitude is not observed, the amount of which is called a common factor [8].

Orthogonal factor model can be used identify factors that influence college student decision making that allow service providers to develop more effective marketing strategies to attract and retain student customers. Based on this background, the purpose of this study is to determine the factors that influence the preferences of college students in choosing a SIM card using an orthogonal factor model.

II. ORTHOGONAL FACTOR MODEL

Factor analysis is a statistical method used to analyze a set of observations by examining their intercorrelations to determine whether the observed variations can be explained by a smaller number of underlying categories [8]. Suppose we are given a random vector $\mathbf{X} = (X_1, X_2, ..., X_p)^T$, with a mean vector $\boldsymbol{\mu} = (\mu_1, \mu_2, ..., \mu_p)^T$ and a variance-covariance matrix $\boldsymbol{\Sigma}$. Each σ_{ii} represents the variance of variable X_i, and σ_{ij} denotes the covariance between variables X_i and X_j. The orthogonal factor model assumes the existence of unobserved common factors $F_1, F_2, ..., F_m$ and unique factors $\varepsilon_1, \varepsilon_2, ..., \varepsilon_p$. The model is expressed as $\mathbf{X} - \boldsymbol{\mu} = \mathbf{LF} + \boldsymbol{\varepsilon}$, where $\mathbf{L}$ is the loading matrix, $\mathbf{F}$ is the vector of common factors, and $\boldsymbol{\varepsilon}$ represents the specific factors.

The orthogonal factor model results in a covariance structure for the random vector $\mathbf{X}$, given by $\boldsymbol{\Sigma} = \mathbf{LL}^T + \boldsymbol{\Psi}$, where Ψ is a diagonal matrix of specific variances. For each variable X_i, the variance can be written as $\text{Var}(X_i) = l_{i1}^2 + l_{i2}^2 + ... + l_{im}^2 + \psi_i$, and the covariance between variables X_i and X_j is determined by the shared factor loadings. The communality of a variable, h_i^2, is the proportion of its variance explained by the common factors. When the variables are standardized, the covariance matrix becomes the correlation matrix $\mathbf{R}$, which is used as the basis for further factor extraction [9].

Several criteria can be used to determine the appropriate number of factors. The percentage of variance criterion requires that the cumulative variance explained by the selected factors be at least 80%. The eigenvalue criterion suggests retaining factors with eigenvalues greater than the average; in the correlation matrix, the average eigenvalue is 1. The scree plot method involves identifying a point where the eigenvalues drop sharply and then level off, selecting the number of factors before the flattening occurs. The most common estimation methods for factor analysis are Principal Component Factoring (PCF), Principal Axis Factoring (PAF), and Maximum Likelihood. In this study, the PCF method is used, which simplifies the structure of the data by reducing the dimensionality and highlighting the underlying factor structure.

To estimate the parameters, such as factor loadings and communalities, a random sample $X_1, X_2, ..., X_n$ is taken, and the sample covariance matrix S is computed. Eigenvalues and eigenvectors of S are then obtained, and the loading matrix $\hat{\mathbf{L}}$ is constructed using the top m eigenvalue-eigenvector pairs. The specific variances $\hat{\psi}_i$ are estimated from the diagonal elements of $\mathbf{S} - \hat{\mathbf{L}}\hat{\mathbf{L}}^T$, and the communalities $\hat{h}_i^2$ are calculated as the sum of squared loadings for each variable. The proportion of total sample variance explained by the j-th factor is given by the ratio of the eigenvalue λ_j to the trace of S or R, depending on the input matrix used.

To enhance interpretability, the factor loading matrix may be rotated. Orthogonal rotation methods, such as Varimax, are often used when common factors are assumed to be uncorrelated. In an orthogonal rotation, the rotated loading matrix $\hat{\mathbf{L}}^* = \hat{\mathbf{L}}\mathbf{T}$, where T is an orthogonal rotation matrix satisfying $\mathbf{TT}^T = \mathbf{I}$. This transformation retains the same estimated covariance structure, ensuring that the interpretation of the factors does not alter the model's validity. Factor scores, which quantify each individual's association with the identified factors, can be computed using several methods, including Bartlett, regression, and Anderson-Rubin. In this study, the Anderson-Rubin method is used, where factor scores are obtained via $\mathbf{F} = \mathbf{XA}$, with $\mathbf{A}$

= $S^{-1}L$. These scores are useful for hypothesis testing, individual comparisons, and building predictive models.

III. RESEARCH METHOD

The data used in this study are primary that obtained through a survey. The variables included in this study are based on the preferences of several researchers [10-17] including having a wide telephone network (X_1), speed and quality of data network (X_2), having services in the form of SMS, MMS, WAP (X_3), affordable telephone and SMS rates (X_4), cheap starter number prices (X_5), affordable electric credit top-up prices (X_6), affordable voucher credit top-up prices (X_7), comprehensive distribution channels to various cities (X_8), easy credit top-up (X_9), promotions and discounts (X_{10}), providing attractive bonuses (such as giving bonuses for making free calls to fellow users every time they top up credit) (X_{11}), operators who are responsive in serving consumers (X_{12}), operators who are polite to consumers (X_{13}). Based on the data sources and variables used, the research was analyzed in stages, namely:

1. Estimating the orthogonal factor model, Estimation of the orthogonal factor model is carried out using techniques such as the principal factor or the principal component method.
2. Determining the number of factors to be used in the factor analysis. The number of factors is determined using the percentage of variance.
3. Performing factor rotation. Perform factor rotation to facilitate the interpretation of the results of the factor analysis. Factor rotation is carried out using the varimax method.
4. Interpreting the results of the factor analysis after factor rotation to identify the factors that influence the observed variables more clearly and easily understood.
5. Calculating the score factor based on the orthogonal factor model, the score factor is used for further analysis or modeling involving these factors.
6. Making conclusions from the results of the orthogonal factor model analysis that has been carried out.

IV. RESULT AND DISCUSSION

The study of factors that influence consumer preferences in choosing SIM cards is very important, especially in the highly competitive telecommunications industry. Consumer preferences can be influenced by various aspects such as price, service quality, network coverage, customer service, and promotion and brand image. By understanding these factors, telecommunications companies can design more targeted marketing strategies, increase customer retention, and develop products and services that suit market needs. This knowledge also helps in more accurate market segmentation, so that companies can allocate resources more efficiently [17].

In addition, changes in consumer behavior triggered by the development of digital technology, mobile internet trends, and data-based services require companies to periodically evaluate the determinants of consumer preferences. Empirical research such as that conducted by Ahmed et al. shows that service attributes such as network reliability and data rates are key elements in SIM card purchasing decisions in developing countries. Therefore, an in-depth study of these factors is not only relevant for marketers, but also for policymakers and regulators in formulating fair policies and encouraging healthy competition in the telecommunications industry [18].

Table 1. Descriptive Statistics of Each Variable

Variable	Q_1	Median	Mean	Q_3
X_1	80.00	90.00	87.84	100.00
X_2	85.00	95.00	91.30	100.00
X_3	50.00	70.00	64.87	80.00
X_4	60.00	80.00	70.64	90.00
X_5	60.00	80.00	73.22	90.00
X_6	75.00	85.00	80.70	95.00
X_7	73.00	82.00	78.59	90.00
X_8	80.00	85.00	82.55	95.00
X_9	80.00	85.00	81.01	94.00
X_{10}	75.00	90.00	81.60	95.00
X_{11}	65.00	80.00	74.48	90.00
X_{12}	60.00	80.00	73.94	90.00
X_{13}	70.00	80.00	75.40	90.00

Table 1 presents a summary of descriptive statistics of 13 different variables. Based on the table, it can be seen that the minimum value range of each variable is 1.00, while the maximum value varies. The median value, which is the middle value of the data, tends to range from 80 to 95 for most variables. This indicates that most of the data is concentrated around this range of values. In addition, the first quartile (Q_1) and third quartile (Q_3) values also show a fairly even distribution of data, although there are some variables with narrower interquartile ranges. Overall, this table provides an initial overview of the distribution characteristics of each variable.

The sample variance-covariance matrix is used to understand the relationship between variables in a dataset. It not only provides information about the individual variability of each variable, but also reveals the extent to which the variables are correlated with each other.

$$S = \begin{array}{c} X_1 \\ X_2 \\ X_3 \\ \vdots \\ X_{13} \end{array} \overset{\begin{array}{ccccc} X_1 & X_2 & X_3 & \cdots & X_{13} \end{array}}{\begin{bmatrix} 159.4053 & 82.1177 & -13.9386 & \cdots & 72.0202 \\ 82.1177 & 129.1340 & -6.6940 & \cdots & 37.3142 \\ -13.9387 & -6.6940 & 681.5058 & \cdots & 190.6162 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 72.0202 & 37.3142 & 190.6162 & \cdots & 571.6949 \end{bmatrix}}$$

This variance provides information about how much the data is spread around the mean for each variable. For example, the variance for variable X3 is the highest, which is 681.505867, which shows that X_3 has the widest spread of data compared to the other variables. The covariance between two variables shows how the two variables move together, a positive covariance indicates that the two variables tend to increase together, while a negative covariance indicates that when one variable increases, the other tends to decrease. A higher covariance between certain variables indicates that they have a stronger relationship with each other.

The number of selected factors is based on the cumulative proportion of explained variance. Table 2 shows the eigenvalues of the variance-covariance matrix, arranged from largest to smallest. Factor 1 has the highest eigenvalue of 2618.0610 and explains 43.67% of the total variance. Factor 2 explains 12.48%, Factor 3 explains 10.99%, and Factor 4 explains 6.87%. Factor 5 and Factor 6 contribute 5.46% and 5.11%, respectively. Together, these six factors explain 84.61% of the total variance, meaning they are sufficient to represent the data. The factor loading shows how strongly each original variable relates to the factors, while communality shows how much of each variable's variance is explained by the factors. These values help us understand the contribution of each variable to the overall factor structure. Communality is the amount of variance of a variable that can be explained by the existing factors. Communality is the sum of the squares of each factor loading of a variable. Suppose the communality of X_1 is $4.652^2 + 4.506^2 + \ldots + 4.750^2 + 0.823^2 = 66.847$.

Next is the determination of the significance of the loading value. According to Hair, et. al (2010), the coefficient is considered significant if the loading value is 0.5 or more. Because the greater the loading value, the stronger the factor is against the variable. In the previous results, the loading value could not determine which variables were included in which factors, so a rotation process, namely varimax rotation, would be carried out to facilitate interpretation.

Table 3 presents the results of the loading factors after applying varimax rotation. The results of the rotation process show a clearer and more realistic distribution of variables. After the rotation process, the covariance between variable X_1 and factor 3 is the largest, with a loading value of 6.886. Meanwhile, the covariance between variable X_1 and factor 6 is the smallest with a loading value of 0.834, so that variable X_1 can be included as a component of factor 3. Variable X_2 has the highest loading factor value on factor 3, with the value of 6.901, so this variable can be included in factor 3.

Table 2. Eigenvalues of the Sample Variance Covariance Matrix

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Eigen Value	2618.0610	748.5180	659.1970	412.1940	327.8020	306.6910
Proportion	0.4367	0.1248	0.1099	0.0687	0.0546	0.0511
Cumulative Proportion	0.4367	0.5615	0.6715	0.7402	0.7949	0.8461

Variable X_4 records its highest loading on factor 1 at 16.039, placing it under factor 1. Similarly, variables X_5, X_6, and X_7 are also linked to factor 1, with their highest loading values being 19.405, 15.586, and 16.264, respectively. Variable X_8 is best represented by factor 3, with a loading value of 14.961. Meanwhile, variable X_{10} aligns most strongly with factor 4, as shown by its highest loading of 12.953. Variable X_{11} loads highest on factor 6 with a value of 23.442. Lastly, variables X_{12} and X_{13} exhibit their strongest associations with factor 2, having loading values of 19.595 and 21.692, respectively.

Through factor analysis, several key factors were identified that influence college student preferences in choosing a SIM card. The price factor plays a significant role, encompassing affordable call and SMS rates, low-cost starter SIM cards, and reasonably priced top-up options, both electronic and voucher-based. The service factor highlights the importance of responsive and polite customer service. The quality and distribution factor reflects the value students place on wide network coverage, fast and reliable connections, and an extensive distribution network across various cities. The convenience and offers factor include ease of top-up and the attractiveness of promotions and discounts. Additionally, the additional services factor refers to the availability of features such as SMS and WAP, while the bonus factor emphasizes the appeal of attractive bonuses provided by the service provider.

Based on the 6 factors that have been formed and described above, the variance of the original variables that can be explained by each factor as in Table 4. Table 4 presents the explained variance percentages for six extracted factors. Factor 1 accounts for the highest proportion of variance at 21.81%, followed by Factor 2 with 17.27%.

Table 4. Explained Variance Percentage of Each Factor

Factor	Explained Varinace Percentage
1	21.81
2	17.27
3	8.26
4	10.19
5	14.94
6	12.14

Factor 5 explains 14.94% of the variance, while Factor 6 and Factor 4 contribute 12.14% and 10.19%, respectively. Factor 3 explains the least variance among the six, at 8.26%. These values indicate the relative importance of each factor in explaining the variability in the dataset.

V. CONCLUSSION

Based on the results of the orthogonal factor analysis, it can be concluded that student preferences in selecting SIM cards are influenced by six main factors, namely price, service, quality and distribution, convenience and offers, additional services, and bonuses. The factor analysis successfully reduced the 13 original variables into six uncorrelated underlying factors, which together explained 84.61% of the total variance. The highest contributing factor is the price factor, which highlights the importance of affordability for college students.

Table 3. Loading and Communality Values with the PCF Method Using Variance-Covariance Rotated

Variable	F_1	F_2	F_3	F_4	F_5	F_6	Communality	Specific Variance
X_1	1.985	2.286	6.886	2.695	-1.519	0.834	66.847	92.558
X_2	0.528	0.520	6.901	2.566	-0.665	0.241	55.252	73.882
X_3	1.894	3.759	0.877	3.053	24.936	1.170	650.996	30.509
X_4	16.039	5.399	-3.798	-2.237	14.690	4.794	544.610	102.34
X_5	19.405	2.768	7.949	-0.374	3.256	2.479	464.310	88.621
X_6	15.586	1.583	2.282	6.075	-0.036	2.239	292.537	110.628
X_7	16.264	4.588	1.642	8.892	0.954	4.562	389.047	122.64
X_8	2.133	1.869	14.961	-2.122	3.367	2.348	253.234	44.077
X_9	4.781	7.423	4.266	14.418	2.371	1.522	341.811	61.837
X_{10}	7.083	3.152	5.438	12.953	1.129	9.572	350.354	92.308
X_{11}	6.506	5.660	3.738	4.103	2.531	23.442	661.134	16.702
X_{12}	5.972	19.595	4.473	2.776	2.866	3.665	468.984	48.090
X_{13}	1.773	21.692	2.969	5.658	3.249	2.872	533.346	38.348

This includes cheap starter SIM card prices, affordable call and SMS rates, and top-up costs. In addition, the service factor, marked by the responsiveness and politeness of the operator, also emerged as a strong determinant of preference.

This research provides empirical evidence that can help telecommunications service providers design marketing strategies that better meet the specific needs of student users. By focusing on the identified factors—particularly price competitiveness, quality customer service, and attractive promotional offers—providers can enhance customer satisfaction and loyalty. Furthermore, the orthogonal factor model approach used in this study proved effective in simplifying the complex relationship between various influencing variables, making it easier to interpret and apply the findings. Future research can expand on this work by incorporating demographic and psychographic variables to gain a more comprehensive understanding of consumer behavior in the telecommunications sector.

REFERENCES

1. Brown, J. 2019. *Information and Communication Technology: The Impact on Daily Life*. Journal of Information Technology, 5(3), 234-256.
2. Harmen, T., Siburian, B., Pitaloka, D., Dongoran, D., & Amelia, B. 2024. Pengaruh Fasilitas dan Layanan Komunikasi terhadap Kepuasan Mahasiswa di Universitas HKBP Nommensen Pematangsiantar. Jurnal Ilmiah Ekonomi dan Manajemen Vol. 2, No. 6, Hal: 612 - 625.
3. Smith, L. 2020. Customer Service and Network Stability in Telecommunications. Journal of Marketing Research, 9(4), 210-225.
4. Johnson, T. 2019. Internet Access and Its Importance for Academic Purposes. Journal of Internet Studies, 8(1), 145-160.
5. Williams, K. 2018. Promotions and Bonuses in Telecom Marketing. Journal of Marketing Strategies, 6(3), 123-138.
6. Spearman, C. 1904. General Intelligence, Objectively Determined and Measured. American Journal of Psychology, 15(2), 201-293.

7. Santoso, S. 2010. Statistik Multivariat. Jakarta: Elex Media Komputindo.
8. Johnson, R. A., & Wichern, D. W. 2007. *Applied Multivariate Statistical Analysis* (6th ed.). Pearson Education.
9. Harman, H. H. 1976. *Modern Factor Analysis* (3rd ed.). University of Chicago Press.
10. Lupiyoadi, R., & Hamdani, A. 2006. Service Marketing Management. Jakarta: Salemba Empat.
11. Kotler, Philip. 2008. *Prinsip-prinsip Pemasaran*. Jakarta: Erlangga.
12. Suryanto, T. 2017. Consumer Preferences in Telecommunication. Yogyakarta: Gadjah Mada University Press
13. Isman, A. 2002. Pengantar Teori Telekomunikasi. Bandung: Informatika.
14. Li, H. 2018. Consumer Behavior in Mobile Communication. Beijing: China Mobile Press.
15. Hidayat, D. (2020). Strategi Promosi pada Industri Telekomunikasi. Jakarta: Rajawali Pers.
16. Parasuraman, A., Zeithaml, & Berry, L. L. 2002. Service Quality and Marketing Strategies. New York: Free Press.
17. Kotler, P., & Keller, K. L. (2016). *Marketing Management* (15th ed.). Pearson Education.
18. Ahmed, S., Hafeez, M., & Ahmad, M. (2014). *Factors affecting the customer's selection of telecommunication network providers in Pakistan*. European Journal of Business and Management, 6(23), 164–176.