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Aplicación del Análisis Factorial para la Identificación de Agrupación de Casos en Telefonía Móvil

Application of Factor Analysis for Identification of Case Grouping in Mobile Telephony

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ABSTRACT.
With the opening of the market, competition in the Brazilian telephony sector has become fierce. In this new scenario, a fundamental question arises regarding the evaluation of customers for the provision of services by providers. In this sense, the aim of this study is to apply factor analysis to describe a set of variables related to mobile consumer satisfaction by a smaller number of dimensions. The research was carried out with the help of SPSS software through which factor analysis was applied to create groupings of variables based on their relationship structure. The number of factors was chosen from the Kaiser criterion and the designated was the orthogonal rotation method - Varimax. The degree of explanation achieved by the two factors of the model corresponds to almost 69% of the variance of the original data. Thus, more than determining which indicators should be used to evaluate the results of mobile phone companies, factor analysis can be used to determine the importance in explaining the variables related to customer satisfaction that uses these services.

Keywords: Mobile Phone Sector, Consumer Satisfaction, Factor Analysis.

RESUMEN.
Con la apertura del mercado, la competencia en el sector de telefonía brasileño se volvió feroz. En este nuevo escenario, surge un tema fundamental en cuanto a la evaluación de los clientes para la oferta de servicios de los proveedores. En este sentido, el objetivo de este estudio es aplicar el análisis factorial para describir un conjunto de variables relacionadas con la satisfacción del consumidor móvil por un número menor de dimensiones. La investigación se llevó a cabo con la ayuda del software SPSS mediante el cual se aplicó el análisis factorial para crear agrupaciones de variables en base a su estructura de relación. El número de factores se eligió a partir del criterio de Kaiser y el designado fue el método de rotación ortogonal - Varimax. El grado de explicación alcanzado por los dos factores del modelo corresponde a casi el 69% de la varianza de los datos originales. Así, más que determinar qué indicadores se deben utilizar para evaluar los resultados de las empresas de telefonía móvil, el análisis factorial puede utilizarse para determinar la importancia en la explicación de las variables relacionadas con la satisfacción del cliente que utiliza estos servicios.

Palabras clave: Sector de la Telefonía Móvil, Satisfacción del Consumidor, Análisis Factorial.

1 INTRODUCTION

Organizations in general need to adapt to the globalized world and seek constant improvement in their activities, through continuous external and internal evaluations of their products and services. The services sector has a large participation in the composition of the Brazilian Gross Domestic Product (GDP) and represents about 70% of the national GDP and ended 2021 with growth of 10.9%, according to the Brazilian Institute of Geography and Statistics (IBGE, 2022). For organizations to advance in this sector and achieve excellence in the services they offer, they need to be concerned about the quality employed in the performance of their operations.

Services are tasks with economic purposes that produce value and provide benefits to the consumer in certain occasions and environments, such as implying the execution of a desired modification on behalf of those who receive the service (Lovelock e Wright, 2001). In this sense, the quality of the service is indispensable for the success of a service provider, due to its influence on consumer satisfaction. Furthermore, for a buyer to want to acquire a service it is necessary that he has a high expectation related to the quality of the service and from the perspective of consumer loyalty, it makes it necessary to meet the expectations and needs of the service provider.

In the other hand, it is important to say that Brazil is at 66° in relation to the Information and Communication Technology Development Index, according to the International Telecommunications Union (ITU, 2005). Also, according to the ITU, Brazil was in position 73, among 167 countries, in 2010, so the country must continue to develop its information and communication technologies so that it can achieve levels of excellence in the quality of meeting consumer requirements, according to the global level of development. Among the various areas of the service sector are information services that encompass telecommunications. In this area there are several variants that condition competitiveness, such as mobile telephony services. It is intended here to develop a successful factor analysis, so that by reducing the number of elements to be treated in the initial set of data, it is a condition of interpretability of the relationships between the variables that represent the investigation on the satisfaction of the mobile telephony consumer.

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These services are linked to the daily life of the user, so the better the activity performed by mobile phone providers, the better it will be for the population that will encounter fewer problems related to the use of the technology they have hired. In addition, according to Anatel (2015), the waiting time to talk to the attendant when on calls to the operator is up to 60 seconds after the selection of this option, so the standard regulated by Anatel must be followed so that customer service is more efficient.

However, the analysis of the variables is usually performed in a univariate way providing indicators without the influence of the other variables involved. Thus, each of these variables also contributes to obtaining the indicator. The question is: Should the importance of each of the variables be considered equally in the preparation of the final indicator? By assumption, managers know that variables do not have the same importance and should be considered differently. Thus, how to evaluate all variables together and define which are the most influential? In this study, a method capable of indicating the importance of each of these variables will be proposed through the statistical technique of Factor Analysis. Thus, it is intended to indicate the main factors and variables that will be composing the satisfaction indicator of mobile phone users Goiás, state of Brazil.

2 THEORETICAL FRAMEWORK

2.1 MOBILE PHONE SECTOR IN BRAZIL

The mobile phone sector in Brazil has undergone major restructuring since the late 1990s, when it was privatized. Following an international trend, observed in countries such as the USA, England, France, Japan, Germany and also in Latin American countries, such as Mexico, Chile, Argentina, Peru and Bolivia, the privatization process of mobile telephony in Brazil, initiated in 1995, lasted until 1998. It understood, among other factors, the end of the state monopoly, the privatization of telephone companies and the approval of the General Telecommunications Law, which set the legal conditions for operation of the sector and the creation of a regulatory agency, the National Telecommunications Agency (Anatel). The changes made by the federal government in the regulatory system, which governs the provision of communication services in the country (PIRES 1999; NOVAES, 2000; NEVES, 2002).

radically modified the institutional context in force 20 years ago. As a result, Brazil ended 2007 with a total of 121 million mobile phones in use (ANATEL, 2020).

2.2 CONSUMER SATISFACTION

Kotler (2005) declares that satisfaction is the feeling that the person has when analyzing the understood performance of a product and compare with their expectations. If expectations are not met the customer will be totally dissatisfied, if you meet a part of the expectation, they will be almost satisfied and if you can meet all expectations, you will leave the customer fully satisfied. Ferrell and Hartline (2009) agree with Kotler (2005) to state that satisfaction is the conception of consumer expectations and how it was built.

For Las Casas (2000) it is necessary to consider the culture, social and psychological aspects of people, because these particularities can affect consumer satisfaction. Las Casas (2000) also says that the importance of serving the consumer should be passed on to employees, for the purpose of satisfying them, but that it is not only techniques, but an integrated philosophy. They need to understand and be convinced to satisfy customers on a day-to-day.

2.3 FACTOR ANALYSIS

According to Bartholomew (1984), "factor analysis is a widely statistical technique, but its theoretical foundations are somewhat obscure and subject to dispute." However, the works of Charles Spearman and Karl Pearson are attributed to the first steps of factor analysis (ZELLER; CARMINES, 1980). Spearman (1904) tested the hypothesis that different tests of mental ability - skills in mathematics, verbal, logical reasoning, among others - could be explained by a common intelligence factor that he called "g". According to Kaplunovsky (2009), another relevant contribution was made by Thurstone (1934) in developing the idea of multiple factor analysis. Other significant contributions can be credited to Hotelling by proposing "the main component method that allows the calculation of the only array of orthogonal factors" (KAPLUNOVSKY, 2004).

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But what is factor analysis for? According to King (1986) "in the factor analysis model, there are many variables observed whose objective is to generate unobserved underlying factors. That is, the main function of different factor analysis techniques is to reduce a large number of variables observed in a smaller number of factors. But what are factors? Hair et al. [18] define factor as the linear combination of the original variables (statistics).

3 METHOD

3.1 DATA ANALYSIS

In its current form, the survey has been conducted annually since 2015 and measures consumer satisfaction and the quality of fixed, mobile, fixed broadband and pay TV services, simultaneously. Descriptive reports are prepared by a research company hired to carry out the interviews. From 2015 to 2019, they present detailed results by service and year, including all overall satisfaction and perceived quality scores, sociodemographic information, samples and methods. Anatel's reports and presentations are written by Anatel itself and focus on the main highlights identified by the research coordination team. A spreadsheet with the results of all the survey indicators and the raw data of each interview (unidentified interviewees) can be downloaded from the following links, along with their respective glossaries: https://www.gov.br/anatel/pt-br/consumidor/compare-as-prestadoras/pesquisa-de-satisfacao-e-qualidade.

In the application of factor analysis, sixteen satisfaction indicators related to 77 respondents were analyzed, based on the year 2020 and the state of Goiás in Brazil. The indicators considered in this study were:

- Indicator 1: Level of general satisfaction of the interviewee with the provider mentioned.
- Indicator 2: Grade awarded with respect to the ease of understanding of the plans and services contracted.
- Indicator 3: Note awarded with respect to the commitment of the operator to fulfill what was promised and disclosed in its advertising.
- Indicator 4: Notes attributed to the ability to make and receive calls.

- Indicator 5: Notes attributed to the quality of the connections (noise, interference).
- Indicator 6: Notes attributed to the ability to access the 3G/4G internet whenever I need it.
- Indicator 7: Notes attributed to the ability to maintain the connection without falls.
- Indicator 8: Notes assigned to navigation speed.
- Indicator 9: Notes attributed to the collection of amounts in the account according to the con-treaty.
- Indicator 10: Notes attributed to the clarity of the information in the account.
- Indicator 11: Notes assigned to the waiting time to talk to the attendant.
- Indicator 12: Notes attributed to the need to repeat the demand.
- Indicator 13: Notes attributed to the ability of the attendants to clarify.
- Indicator 14: Notes attributed to the quality of the operator's telephone service.
- Indicator 15: Notes attributed to the quality of internet service of the operator.
- Indicator 16: Notes attributed to the quality of service in the operator's store.

3.2 STEPS OF APPLICATION OF FACTOR ANALYSIS

The steps followed in the preparation of a factor analysis are:

1. Calculation of the correlation matrix: at this stage, the degree of relationship between the variables and the convenience of the application of factor analysis is evaluated.

2. Extraction of factors: determination of the method for calculating the factors and defining the number of factors to be extracted. At this stage, it seeks to find out how much the chosen model is appropriate to represent the data.

3. Rotation of factors: a stage in which it is sought to give greater inter-blackness capacity of the factors.

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4. Calculation of scores: the scores resulting from this phase can be used in several other analyses (discriminant analysis, cluster, logistic regression, among others.).

The research was carried out with the help of SPSS® for Windows software.

4 RESULTS AND DISCUSSIONS

4.1 INITIAL SETTINGS

As the research is intended to identify a minimum number of factors that will explain the maximum portion of the existing variance in the original variables, the method chosen was principal component analysis.

In this case factor analysis will create groupings of variables based on their relationship structure. This type of analysis is called R-mode factor analysis.

The number of factors will be chosen by the Kaiser criterion (explained variance of at least 1.0). In this way, factors that explain a value of variance less than the ability to explain the variables themselves study will not be treated.

The orthogonal rotation method - Varimax was chosen, because the intention is to facilitate as soon as possible the understanding of the underlying relation-ships between the variables (factors). Since oblique methods create relationships between factors, this would produce even more complex relationships for subsequent analyses.

4.2 APPLICATION OF FACTOR ANALYSIS

The factors were established using all indicators at the same time. The Kaiser-Meyer-Olkin (Measure of Sampling Adequacy - MSA) test in Table 1 indicates the degree of explanation of the data from the factors found in the factor analysis. If the MSA indicates a degree of explanation less than 0.50, means that the factors found in the factor analysis cannot satisfactorily describe the variations of the original data.

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TABLE 1 - KMO AND BARLETT TEST

Kaiser-Meyer-Olkin measure of sampling adequacy		0.93
Bartlett's Scouting Test	Aprox. Qui--square	1,173.88
	df	120
	Sig.	-

SOURCE: The authors (2022)

In this case, the test indicated a high power of explanation between the factors and the variables (0.93). Another test that can be visualized in Table 1 is Bartlett's Scouting, which indicates whether there is a sufficient relationship be-tween those indicated for the application of factor analysis. In the case analysis application, it is recommended that the Sig value be possible. (Significance test) does not exceed 0.05. If this occurs, and it is likely that the correlation of the indicators is exceedingly small, which prevents application of factor analysis. If the value of Sig. 0.10, factor analysis is inadvisable. Therefore, the scouting test indicated the possibility of applying factor analysis to the variables analyzed (0.000).

Although some variables have little relation to the factors, most indicators achieved (in the attempt with all indicators) have a high power of explanation, considering all the factors obtained (commonalities). Of course, some obtained reasonable explanations (below 0.70). This can be observed in the Communalities table (Table 2).

TABLE 2 - COMMUNALITIES

	Initial	Extraction
Indicator 1	1.0000	0.8029
Indicator 2	1.0000	0.1599
Indicator 3	1.0000	0.7768
Indicator 4	1.0000	0.6191
Indicator 5	1.0000	0.5852
Indicator 6	1.0000	0.7240
Indicator 7	1.0000	0.7399
Indicator 8	1.0000	0.8422
Indicator 9	1.0000	0.7067
Indicator 10	1.0000	0.6480
Indicator 11	1.0000	0.7185
Indicator 12	1.0000	0.8220
Indicator 13	1.0000	0.8362

Indicator 14	1.0000	0.8837
Indicator 15	1.0000	0.6448
Indicator 16	1.0000	0.5026

SOURCE: The authors (2022)

One more analysis that can be made is the degree of explanation achieved by the two factors that were calculated by factor analysis. Regarding this indicator, the model can explain almost 69% of the variance of the original data, which is relatively good. You can see this in the Total Variance Explained table (Table 3).

TABLE 3 - TOTAL VARIANCE EXPLAINED

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Square Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.987	62.420	62.420	9.987	62.420	62.420	7.584	47.400	47.400
2	1.025	6.409	68.828	1.025	6.409	68.828	3.429	21.428	68.828
3	0.970	6.060	74.888						
4	0.839	5.245	80.133						
5	0.615	3.846	83.979						
6	0.570	3.564	87.543						
7	0.433	2.703	90.246						
8	0.336	2.099	92.345						
9	0.261	1.632	93.976						
10	0.254	1.587	95.563						
11	0.176	1.098	96.661						
12	0.153	0.954	97.616						
13	0.141	0.884	98.499						
14	0.106	0.665	99.165						
15	0.075	0.466	99.630						
16	0.059	0.370	100.000						

SOURCE: The authors (2022)

Thus, it is believed to have reached a degree of relationship and explanation of the variables capable of being useful in the evaluation of mobile phone companies. It is now necessary to identify which indicators are part of each of the fac-tors. The Component Matrix

table (Table 4) allows you to verify which of the factors best explains each of the indicators considered.

TABLE 4 - COMPONENT MATRIX

	Component	
	1	2
Indicator 1	0.896	0.022
Indicator 2	0.289	-0.276
Indicator 3	0.880	0.045
Indicator 4	0.733	-0.285
Indicator 5	0.727	-0.239
Indicator 6	0.835	-0.165
Indicator 7	0.838	-0.196
Indicator 8	0.896	-0.99
Indicator 9	0.837	-0.076
Indicator 10	0.801	0.077
Indicator 11	0.839	0.117
Indicator 12	0.891	0.167
Indicator 13	0.894	0.191
Indicator 14	0.921	0.188
Indicator 15	0.283	0.751
Indicator 16	0.699	0.116

SOURCE: The authors (2022)

It is noticed, however, that this matrix causes doubts regarding the composition of each factor, since there are very close values of explanation in some cases. In these cases, it is up to the verification of the values after the application of the rotation of the factors, in this example it is done by the Varimax criterion (Table 5).

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TABLE 5 - ROTATED COMPONENT MATRIX

	Component	
	1	2
Indicator 1	0.755	0.483
Indicator 2	0.390	-0.086
Indicator 3	0.730	0.494
Indicator 4	0.775	0.136
Indicator 5	0.745	0.172
Indicator 6	0.799	0.291
Indicator 7	0.818	0.266
Indicator 8	0.870	0.293
Indicator 9	0.755	0.369
Indicator 10	0.646	0.481
Indicator 11	0.657	0.535
Indicator 12	0.676	0.604
Indicator 13	0.666	0.627
Indicator 14	0.690	0.638
Indicator 15	-0.147	0.789
Indicator 16	0.539	0.461

SOURCE: The authors (2022)

The matrix, after rotation of the factors (Rotated Component Matrix), already allows a more accurate classification of the indicators in each of the factors. The criterion for the composition of each factor is defined by the proximity of its explanation values. Thus, we can conclude that:

- Factor 1 consists of Indicator 1, Indicator 3, Indicator 4, Indicator 5, Indicator 6, Indicator 7, Indicator 8 and Indicator 9.

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- Factor 2 consists of Indicator 2, Indicator 10, Indicator 11, Indicator 12, Indicator 13, Indicator 14, Indicator 15 and Indicator 16.

Once the composition of the factors has been identified, it is necessary to verify whether it is possible to interpret this composition. In our model, it was possible to interpret the first factor as being the "Mobile telephony quality" and the second factor can be interpreted as being an indication of "Quality of customer service".

5 CONCLUSIONS

Customer satisfaction tends to lead to repurchase, acceptance of other products or recommendation. Knowledge of the factors that affect satisfaction and loyalty is essential for companies operating in competitive markets such as mobile telephony in Brazil, as well as for Anatel's regulatory performance.

A factor analysis can be considered successful when, by reducing the number of elements to be treated in an initial set of data, it creates the condition of interpretability of the relationships between variables. Thus, the objective of the study was successfully fulfilled, since the set of 16 original variables pertinent to the satisfaction of the mobile telephony consumer was reduced to 2 factors by applying factor analysis.

The degree of explanation achieved by the two factors can explain almost 69% of the variance of the original data, which is relatively good.

However, it is necessary to clarify to researchers that they will make use of factor analysis that, because this technique uses as the main source for their calculations a correlation matrix, it becomes vulnerable to the situation of spurious correlation. Thus, the quality of the information generated will be directly related to the quality of the information that is submitted to factor analysis. The data analysis phase, in this case, should be careful to obtain a good result with factor analysis.

It is suggested to perform future work, a qualitative analysis with in-depth interview with each interviewee, in order to better understand the strategic reality that leads to the satisfaction of the mobile telephony consumer. This interview could capture results that are not obtained through surveys, allowing a deepening of this study. Finally, because it is a service

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area, an analysis with different periods of data collection would be relevant for comparison purposes.

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