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Article

Measure of customer satisfaction in the residential electricity distribution service using structural equation modeling

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Abstract: The main objective of this study is to apply structural equation modeling with partial least squares and based on covariance to assess the satisfaction of residential electricity consumers. The methodology used compares the results of both structural equation models to indicate the model that best fits the problem of measuring the satisfaction of residential consumers satisfaction with electricity concessionaires and licensees. The sample used in the survey contained questionnaire responses from 86,175 individuals considering the period from 2014 to 2018. The constructs evaluated were satisfaction, quality, value, loyalty, and trust. Confidence interval analysis shows that all weights are significant, demonstrating the importance of all the indicators that represent the constructs. The trust, quality, and value constructs can explain 74.4% of the satisfaction construct variability, so this relationship's explanatory capacity is considered substantial. Finally, the evaluation of the performance of the service provided by the electric energy concessionaires/licensees, measured by customer satisfaction, allows for the continuous improvement of services and meeting, even if minimally, the expectations of its consumers.

Keywords: Residential electricity distribution, PLS-SEM, CB-SEM, quality of service, customer satisfaction.)

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1. Introduction

In several countries, the sectors of essential services such as electricity, water, and sewage, among others, are concerned about the well-being of citizens and the proper provision of services. For survival and profitability in a competitive scenario, service providers must develop tools capable of measuring and supporting the quality management of their services, perceived quality, and behavioral intentions of their customers. In recent decades, studies on customer satisfaction have absorbed some of the efforts of marketing researchers, research institutes, government agencies, and companies that intend to implement total quality management programs. Thus, one of the main objectives of these organizations is to search for customer satisfaction [1]. Owing to the recognition of this management principle, monitoring customer satisfaction is becoming increasingly important to assess the overall performance of companies, including electric utilities [2].

In electricity distribution services, customer satisfaction tends to be measured by technical performance, such as the availability of electricity. Dusky [3] points out that most of these companies are focused on providing electricity and not meeting customer expectations. However, quality of service is an essential element in electricity distribution services, and its consumers are susceptible to different aspects of the quality of this service.

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Today, customers are more informed and reasonable about product supply in the market. Therefore, the evaluation of customer needs and satisfaction can improve service effectively and, consequently, lead to increased approval [4]. Filardi *et al.* [5] reported that the interruption of electricity distribution, lack of quality service, and delay in real be shooting distribution networks have become increasingly frequent in some countries. These problems were the main factors that resulted in customer dissatisfaction, especially for residential customers.

There are many methods to measure customer satisfaction in the literature, and structural equation modeling (SEM) is one of the most commonly used methods. Using SEMs, Zeithaml, Berry and Parasuraman [6] demonstrated that behavioral intentions resulting from the impact of the quality of the services provided could be detected, especially in the company's profit. Some studies emphasize reliability indicators to assess customer satisfaction with energy distribution services. Sullivan [7] proposes to measure customer satisfaction using indicators such as number of electricity service interruptions or power quality problems, total time of shutdown of electricity supply and notification of the outage in question. Similarly, Fumagalli, Garrone and Grilli [8] propose performance measures to analyze the continuity of power supply, punctuality in the processing of customer requests, reliability of the power supply, voltage values and average duration of system interruptions as a measure of satisfaction.

Bearden *et al.* [9] propose a broader perspective, suggesting the use of measures such as frequency of complaints, resolution of complaints, and channels available for resolving complaints. On the other hand, in addition to reliability metrics, Jannadi *et al.* [10] adopt performance indicators such as courtesy, individual attention, immediate care, empathy, assurance, and responsiveness to measure satisfaction.

Several studies measure customer satisfaction in various segments of essential services, but there are only a few concerning electric utilities. This industry must develop tools capable of measuring and supporting the quality management of the services provided, perceived quality, and behavioral customer intention to ensure survival and profitability in a competitive scenario. The proposal of this work induces concessionaires/licensees of electricity to maintain data on the evolution of their indicators of the quality of service, achieving strategies that improve and lead to consumer satisfaction. In addition, in possession of the stored results obtained through this proposal, it is possible to establish an association model for concessionaires/licensees from the view of electricity consumers to facilitate the diagnosis of problems and their possible solutions. Therefore, studies that consider the potentialities arising from structural equation modeling, both with partial least squares (PLS-SEM) and covariance-based (CB-SEM), together with the monitoring of service quality indicators and forecasting in diagnoses, reduce the gap and justify the proposal of this work.

This paper presents the originality of the evaluation model of customer satisfaction applied to the electricity sector using PLS-SEM and CB-SEM and compares the results and evaluation, which is the best model. The PLS-SEM and CB-SEM approach analyze the cause-and-effect relationships between latent constructs [11]; however, they are different in terms of results, basic assumptions, and estimation procedures [12,13]. The PLS-SEM explains the variance of latent constructs by minimizing the assignments of error and maximizing the R^2 values of endogenous constructs [12,14]. At the same time, the CB-SEM, on the other hand, follows the procedure of estimation by maximum likelihood and aims to minimize the difference between the observed and estimated covariance matrix, without focusing on the explained variance [11].

As an innovation, the models of structural equations using multi-group comparisons seek potential changes in the measurement or relationships of constructs, which allows us to evaluate whether the theoretical model is stable. When considering its relevance, replicating the proposed methodology is relevant to other sectors to compare their performance with international benchmarks.

The work developed requires data from the customer satisfaction questionnaires, generally available for completion on the companies' websites, making the research work not computationally costly. It can be applied in monitoring and analyzing customer satisfaction, observing the evolution of the quality of the service provided, and assisting the development of instruments in supporting decision-making with

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concessionaires and electricity licensees. The main objective of this work is to apply structural equation modeling using partial least squares (PLS-SEM) and structural equation modeling based on covariance (CB-SEM) to evaluate the satisfaction of residential electricity customers concerning electric utilities and licensees that provide their services. The secondary objectives of this study are exploratory and descriptive analyses of customer satisfaction index data.

This manuscript has this structure: Section 2 describes some international legislation on the quality of electricity, general concepts about customer satisfaction, brief information on structural equation modeling by partial least squares (PLS-SEM), and structural equation modeling based on covariance (CB-SEM). Section 3 presents the proposed methodology. Section 4 shows the results obtained from the proposed method, and soon after, the results are discussed. The conclusions are presented in Section 5.

2. Theoretical background

We presented a perspective on how electric utilities provide their services in several countries and some aspects of the quality of electricity distribution. The differences between previous expectations and perception of a given product after consumption, factors that lead to customer satisfaction, and the historical perspective of implementing American and European satisfaction index models are also presented here. Finally, we gave structural equation modeling using partial least squares (PLS-SEM) and structural equation modeling based on covariance (CB-SEM).

2.1. Legislations of the quality of electricity

Electric utilities strive to meet customer demands in the most economical way possible, providing service that produces reliability. To meet customer demands, power utilities need constant updating of the distribution system, operated and maintained accordingly. About 90% of all customer reliability issues are due to problems in the distribution system, so improving distribution reliability is critical to enhancing customer reliability [15].

The quality of electricity supplied is provided in international standards and their local derivatives. There are no definite ways to measure residential customer satisfaction with electricity, and different terminologies are used to refer to the quality of electricity in other countries. The two most common energy quality standards currently in use are IEC 61000-4-30 [16] and EN 50160 [17]. IEC 61000-4-30 is the standard that defines methods for monitoring energy quality. Its third edition includes current measurements, unlike previous editions that referred only to the voltage measurement. EN 50160 is the European standard for energy quality, setting acceptable distortion limits for the different parameters that define alternating voltage.

The electricity sector functions as an integrated, vertical monopoly. Typically, customers are required to purchase the product electricity from only the concessionaire or licensees available in their region. Economic regulation controls these monopolies, allowing the establishment of production and sales prices. The traditional function of regulation is to protect customers from monopoly power [18].

In general, there is no international standard for regulatory agencies to measure the quality of the service provided by a concessionaire or electricity permissionary. In the United States and European countries, each region adopts its criteria, which include: i) reliability with system average interruption duration index (SAIDI), system average interruption frequency index (SAIFI), customer average interruption duration index (CAIDI), and customer average frequency index (CAIFI), ii) work accidents, iii) reaction to cable damage, iv) worst circuits in terms of interruptions (duration and frequency), v) attendance to calls (average response time), vi) complaints to the regulatory agency, vii) percentage of meters read monthly by the company, viii) service times for new customer units, and ix) customer satisfaction [19].

SAIDI and SAIFI are the most common in terms of internationally used indexes. There are two main groups of indices used in the United States and Europe: minutes lost per year including SAIDI, customer minutes lost (CML), average system interruption duration index (ASIDI), transformer system average interruption duration index (T-SAIDI), equivalent interruption time related to the installed

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capacity (TIEPI), and the number of interruptions per year that, in addition to SAIFI, include customer interruptions (CI), average system frequency interruption index (ASIFI), transformer average system interruption frequency index (T-SAIFI), and equivalent number of interruptions related to the installed capacity (NIEPI) [20].

In Brazil, the particularities inherent to the quality of customer support are described in the ANEEL Normative Resolution 414/2010 [21]. This disciplinary resolution establishes the general conditions of electricity supply in an updated and consolidated manner, highlighting the quality of commercial assistance, telephone services, and information processing. The quality of the electricity supply service to the Brazilian customer is evaluated according to the interruptions, using individual continuity indicators and collective continuity indicators [22].

2.2. Customer satisfaction

Studies to measure customer satisfaction begins with total quality management and have expanded from the psychosocial perspective generated by marketing specialists [23]. On the other hand, projects in the production area focus on the quality management system (QMS) from the most pragmatic form of satisfaction, with marketing professionals dedicated to exploring the psychology of customer satisfaction from its formation to its impacts on future purchase behaviors [24]. Parasuraman, Zeithaml, and Berry [25] describe service satisfaction as follows:

$$S = P_s - E_s \tag{1}$$

where S is satisfaction, P_s is the perception of service, and E_s is the expectation in the service. Thus, S is considered the response of the evaluation of the differences between uncertain expectations and perceptions after the consumption of a given product [26]. In the analysis of Veljkovic *et al.* [27], customer satisfaction is linked to emotional response, and the feeling of satisfaction occurs by comparing the expectations developed before purchase and the perceived performance of the product or service after the purchase. For happiness to appear, probable customer expectations must be met.

Customer expectations refer to service and delivery, referring to a reference point or standard for the execution of the service, reflecting directly on their perception [27]. In this way, knowledge about customer expectations is central to the development and provision of services in all organizations [28]. Oliver [26] adds that satisfaction is essential to the well-being of customers, contributing to the process of economic stabilization and the political structures of a given nation. Customers increasingly demand the market and expect more attention to meet their needs. Although these guidelines have started as marketing practices, several sectors admit that customers are elementary to their activities, making a considerable investment in training employees for adequate customer service [1].

The first nationwide customer satisfaction index is the customer satisfaction barometer (CSB). The American Customer Satisfaction Index (ACSI) contains specific information about 40 branches from seven North American groups. New Zealand began working with customer satisfaction indexes, and the European Union presently recommended this index in its member countries [29]. Subsequently, Taiwan, Korea, and Brazil conducted the pilot tests [30].

The pilot European Customer Satisfaction Index (ECSI) project, born after the acceptance of the ACSI model, aims to develop an instrument for measuring European market satisfaction more accurately. The ECSI model shares most of its relationship structure between latent variables (such as the ACSI model), so much so that the hypotheses are the same. The difference between the models lies in the relationships resulting from the image variable in the ECSI model, which theoretically has repercussions on expectations, satisfaction, and loyalty [31].

Similar to the ACSI model, the ECSI model addresses two main components: i) a structural model, formed by the set of equations that define the relationship between latent variables and, ii) measurement model, formed by the set of equations that define the relationship between latent variables and measure variables (indicators). The only difference between the models is the inclusion of the image in the ECSI model as an antecedent construct of satisfaction [32].

In Brazil, the ANEEL Customer Satisfaction Index (IASC) compares the performance of Brazilian electricity utilities from customer evaluations. The IASC is composed of five variables: i) perceived quality, ii) perceived value, iii) satisfaction, iv) trust in the supplier, and v) loyalty. The IASC calculation model is based on a qualitative consultation conducted in 2000 and is discussed with ANEEL representatives, national agencies, and electricity distributors.

2.3. Structural equation modeling

Structural equation modeling (SEM) is a technique that analyzes the relationships of dependence, independence, and interdependence between variables through a series of simultaneous multiple regressions [33]. Although causality is somewhat complex, SEM equations aim to analyze its effects. The fundamental purpose of the SEM is to study the influence of X in Y and latent, the impact of Y in Z [34], allowing the study of the relationships between variables in sets of equations, presenting these relationships in the path diagram. In the path diagram, it is possible to check almost all the associations (measured by the model) using a set of geometric shapes and arrows.

SEM requires a theoretical basis for model creation, structural and measurement models as a confirmatory technique. The structural model presents the relationship between latent variables, while the measurement model presents the relationships between the observed variables and the latent variables [35]. The modeling of structural equations is a technique of second-generation multivariate statistical for data analysis, enabling answers to interrelate, systematic, and comprehensive questions. This purpose is achieved by simultaneously modeling relationships between multiple dependent and independent constructs [36,37].

Among the structural equation modeling (SEM) methodologies, there are two in the literature that stand out: i) structural equation modeling by partial least squares (PLS-SEM) and ii) structural equation modeling based on covariance (CB-SEM). The PLS-SEM approach is causal modeling that aims to maximize the explained variance of dependent latent constructs, contrary to the objective of the CB-SEM approach of reproducing the theoretical covariance matrix without focusing on the explained variance [38]. However, both approaches are complementary in the way that the advantages of the nonparametric and variance-based PLS-SEM approach are the disadvantages of the Parametric CB-SEM approach and vice versa [38–40].

3. Methodology

This section presents the methodology used to understand how different indicators contribute to achieving residential electricity consumer satisfaction, assessing the fulfillment of these consumers about concessionaires and licensees that provide electricity distribution services. Therefore, verification is carried out on the instrument and the procedures used for data collection, presenting the process of descriptive data analysis and the construction of structural equation modeling based on partial least squares and structural equation modeling based on covariance. The proposed method is illustrated in Figure 1, with a brief description of the five stages required for the resulting model.

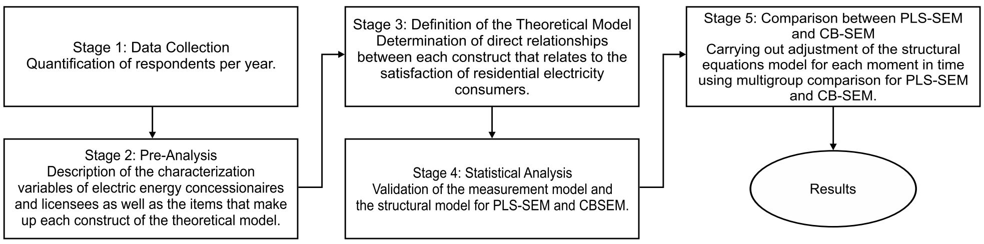

Figura 1. Flowchart of the process of modeling structural equations

3.1. Data Collection

From the electronic system of the citizen information service (SESIC), it is possible to obtain access to the information necessary to calculate the satisfaction of residential electricity consumers. In this way, reference data are obtained regarding the customer's perception of the regulation, production, transmission, distribution, and commercialization of electric energy.

The data obtained by SESIC are generally formatted in a structure for mathematical processing, consisting of recording observations and variables of interest. SESICs were used in most cases .CSV files. The defining variables used were: household, sex, age group, education, family income, and value of the last energy bill, among others.

3.2. Pre-analysis

With the data in hand, pre-treatment was carried out based on the population to be studied. Thus, the population is made up of residential electricity consumers, and the number of respondents varies according to the size of each energy distributor. In describing the qualitative variables characterizing the energy companies and the sample, absolute and relative frequencies are used. In contrast, measures of position, central tendency, and dispersion are used to describe quantitative variables and the description constructs' items.

The grouping analysis of individuals was performed using the non-hierarchical k-prototypes method. The k-prototype grouping combines the k-means and k-modes techniques, allowing the simultaneous use of numerical and categorical variables. In the pre-treatment, after identifying the outliers, it is necessary to verify whether the exclusion of data produces or does not underestimate the analysis results.

3.3. Theoretical Model

In the model proposed for assessing the satisfaction of residential electricity customers, the approach of structural equations in which the main measurement characteristics of the American Customer Satisfaction Index (ACSI) and the ANEEL Customer Satisfaction Index (IASC) are considered. To build a structural equation model that represents the factors that lead to the satisfaction of residential electricity consumers, it is necessary first to elaborate on the theoretical model that determines the multiple dependency relationships between the variables. In this way, the satisfaction, quality, value, loyalty and trust constructs were tested.

In this proposal, **satisfaction** is considered as the assessment of the degree of adjustment of the service provided by concessionaires/licensees of electric energy to the expectations of the customer. **Quality** is the customer's perception of fitness guided by their needs, expectations, and how much the customer perceives the quality in the service provided. **Value** is considered as the assessment of the relationship between costs and benefits perceived by the consumer about electricity services. **Loyalty** is defined as the consumer's commitment to continue consuming the service consistently depending on the tariff, supply, or service, even though they know that they cannot change providers since most of the time there is monopolization of the power distribution service. **Trust** assesses whether consumers consider electricity suppliers to be reliable, concerned about consumers themselves, competent in providing the right services and information providers.

Figure 2 illustrates the direct relationships between each construct. Thus, trust is related to perceived quality, satisfaction and loyalty. Perceived quality is related to value and satisfaction, and value is related only to satisfaction. Finally, satisfaction is related to loyalty.

The theoretical model illustrated in Figure 2 consists of a systematic set of relationships that provide explanations about consumer satisfaction and is not restricted to the theory of consumer satisfaction but is grounded in experience and practice obtained from observation.

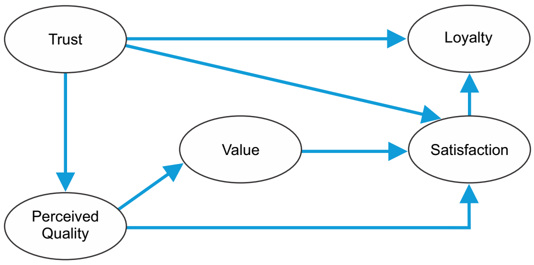

Figura 2. Flowchart for the evaluation of satisfaction of residential electricity consumer.

3.4. Statistical Analysis

To verify the validity of the ability of each construct's set of indicators to accurately represent its respective concept, a measurement model was developed in which dimensionality, reliability, convergent validity, and discriminant validity were evaluated. To verify the dimensionality of the constructs, the Kaiser criterion was used in this study. Convergent and discriminant validity were used as the criterion proposed by Fornell [41], which indicates convergent validity, if the average variance extracted (AVE) is greater than 50% or 40% in the case of exploratory research, while discriminant validity occurs when the AVE of the construct is greater than the shared variance of this construct with others.

Cronbach's alpha (CA) and composite reliability (CR) was used to measure reliability. The CA and CR indicators must be greater than 0.70 to indicate the reliability of the construct, and in experimental research, values above 0.60 are also accepted. To verify the discriminant validity, the cross-factor loading method is used, which indicates discriminant validity when the factor loading of the item is greater than all of its cross-factor loadings.

For the PLS-SEM approach, the bootstrap method was used to calculate the confidence intervals for the weights of the measurement model and the coefficients of the structural model, providing information on the variability of the estimated parameters, thus promoting the validation of the results. In the CB-SEM approach, the model quality parameters were used: comparative fit index (CFI), Tucker-Lewis index (TLI), and root mean square error of approximation (RMSEA), in addition to the *p*-value to verify that the RMSEA is statistically more significant than 0.05. For the desired adjustment, CFI and TLI were expected to be greater than 0.80. The CFI and TLI values vary in the interval [0, 1], and the closer the matter is to 1, the better the model fit. The RMSEA must present an index of less than 0.10, the ideal being below 0.05.

3.5. Method to compare structural equation modeling based on partial least squares and covariance-based SEM

One of the objectives of this work is to compare the results obtained by structural equation modeling: i) based on partial least squares (PLS-SEM) and ii) based on covariance (CB-SEM). The structural equation model and the measurement model were adjusted for each period/time of the analysis, and the models were compared by multigroup to compare the two different techniques.

Multigroup analysis is performed on time series, looking for potential changes in the measure or the relationships of the constructs, allowing the assessment of whether the theoretical model is stable overtime or not. For the formal tests to compare the weights and structural coefficients between times, the Student's *t*-test was used with a grouped standard deviation of the weights or coefficients within the tested models.

4. Results

This section presents the results obtained by applying the proposed methodology. The data used come from concessionaires and licensees of the Brazilian Electricity Regulatory Agency (ANEEL/Brazil). The population for the construction of the database is formed by the set of residential electricity

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consumers interviewed for the composition of the ANEEL Consumer Satisfaction Index (IASC) in the period from 2014 to 2018. The IASC is obtained annually from a sample survey conducted with residential consumers of all distributors, concessionaires, and licensees, who operate in the Brazilian territory. Approximately 27,000 interviews are conducted per year.

4.1. Database Construction

Concessionaires/licensees concentrate their services in urban areas; however, according to current regulations, electricity distribution services are composed of urban and rural consumers. As the number of rural consumers $\approx 5\%$ is lower than that of urban consumers $\approx 85\%$, the needs of rural areas end up being ignored. The annual satisfaction survey conducted by ANEEL uses samples only from urban residential consumers. Other consumers in other categories, such as trade, industry, and government, are not analyzed. Therefore, the IASC evaluates distributors only based on the opinion of urban residents. Table 1 provides the distribution of consumer units (CU) in the various consumption classes for all Brazilian concessionaires/licensees.

Tabela 1. Consumer units by consumption class.

Consumption class	Nº. CU	%
Commercial and Services	1,141,705,208	7.24
Own Consumption	1,968,873	0.01
Streetlight	17,611,665	0.11
Industrial	118,022,560	0.75
Government	115,039,889	0.73
Residential	13,471,190,674	85.45
Rural	854,493,946	5.42
Rural Farmer	6,713,438	0.04
Rural Irrigating	22,061,727	0.14
Civil Service	16,708,356	0.11
TOTAL	**15,765,516,336**	

The research conducted in this work analyzes the satisfaction of the $\approx 85\%$ of the customers of the concessionaires/licensees that are primarily urban residential. The pleasure of other clients is not measured, as they are not considered in the sampling of the annual satisfaction survey conducted by ANEEL. Data for assessing the satisfaction of residential electricity consumers were requested from the ANEEL via the electronic system of the citizen information service (SESIC). For 2014 and 2015, 25,186 interviews were conducted each year, 20,230 of which were interviews in 63 concessionaires and 4,956 interviews in 38 licensees. In 2016 and 2017, 24,926 interviews were conducted each year, with 19,970 interviews held in 63 concessionaires and 4,956 discussions in 38 licensees. In 2018, 23,446 interviews were conducted, 18,490 of which were in the 54 concessionaires and 4,956 interviews in the 38 licensees.

After the construction of the database, a pre-analysis was carried out, treating the data to remove those interviewed who did not answer all the questions. With the processed data, there were: 16,704 individuals in 2014, 19,763 individuals in 2015, 19,782 individuals in 2016, 14,618 individuals in 2017 and 15,308 individuals in 2018, totaling 8,6175 individuals. The questionnaire contained 50 questions, of which 32 questions were related to the constructs satisfaction, quality, value, loyalty, and trust. In contrast, the other questions promote the descriptive analysis of the variables that characterize the sample.

4.2. Descriptive Analysis of Variables

With the database treated, it is possible to perform a descriptive analysis of the variables characterizing the individuals, as shown in Table 2, in which 79.20% of respondents are responsible for the household.

Most individuals were female (61.71%), 21.50% were between 46 and 55 years old, and 20.80% were between 36 and 45 years old, and these were the most frequent age groups. All individuals lived in the interview's home, lived in the city for more than six months, knew the name of the electricity

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company, did not work and had no relatives who worked at the electricity company. All knew the value of the electricity bill.

In most respondents, energy use is exclusively residential, and they do not provide energy to third parties (99.98%). As for the level of education, 35.40% of respondents had not completed elementary school, and 29.30% had completed high school. As for family income, 45.70% of individuals receive from US$3,974 to US$ 9,937 and 31.3% receive annually from US$ 1,807 to US$ 3,974. Thus, 77% of individuals have an annual income between US$ 1,807 and US$ 9,937.

Tabela 2. Descriptive analysis of sample characterization variables.

Variables		N	%
Responsible by domicile	Spouse of the responsible	17,912	20.8%
	Yes	68,263	79.2%
Gender	Male	52,634	61.1%
	Female	33,541	38.9%
Age group	Up to 18 years old	299	0.3%
	Between 18 and 25 years old	5,722	6.6%
	Between 26 and 35 years old	15,036	17.5%
	Between 36 and 45 years old	17,901	20.8%
	Between 46 and 55 years old	18,547	21.5%
	Between 56 and 65 years old	15,492	18.0%
	Over 65 years old	13,169	15.3%
Lives at home	No	0	0.0%
	Yes	86,175	100,00%
Lives in the city for over 6 months	No	0	0.0%
	Yes	86,175	100.00%
Know the name of the concessionaire	No	0	0.0%
	Yes	86,175	100.00%
Works at the electric power company	No	86,175	100.00%
	Yes	0	0.0%
Exclusively residential consumption	No	12	0.0%
	Yes	86,163	100.00%
Has power meter	No	0	0.0%
	Yes	86,175	100.00%
Provides energy to third parties	No	86174	100.00%
	Yes	1	0.0%
Energy supply	Not normal	0	0.0%
	Normal	86,175	100.0%
Know the account value	No	0	0.0%
	Yes	86,175	100.0%
Education level	Incomplete elementary	30,525	35.4%
	Complete elementary	12,082	14.0%
	Incomplete high school	5,969	6.9%
	Complete high school	25,225	29.3%
	Incomplete higher education	3,475	4.0%
	Complete higher education	8,899	10.3%
Annual family income	Less than US$ 1,992.45	9,303	10.8%
	From US$ 1,992.45 to US$ 3,984.91	26,991	31.3%
	From US$ 3,984.92 to US$ 9,962.26	40,938	47.5%
	From US$ 9,962.27 to US$ 19,924.53	7,227	8.4%
	From US$ 19,924.54 to US$ 29,886.79	1,266	1.5%
	From US$ 29,886.80 to US$ 39,849.06	288	0.3%
	More than US$ 39,849.06	162	0.2%
Last account value	Mean (S.D.)	33.79	1,610.72

Table 3 shows the groups × variables used in the grouping process, in which the difference between groups and variable values was observed (p-value < 0.05). There were three groups: **Group 1**, **Group 2**, and **Group 3**. In **Group 1** it was observed that: 87.10% of the individuals interviewed are responsible for the household; 74.60% are men; 28.80% are aged between 46 and 55 years; 64.30% have completed high school with an annual family income between US$ 3,974 and US$ 9,937 and 55.10% paid more than US$ 28.95 in the last amount of the electricity bill.

Group 2 contained 78.10% of the interviewed individuals responsible for the household, 74.10% were women over 60 years old, 75.8% had only incomplete primary education, and 47.8% had an annual family income between US$ 1,807 and US$ 3,974. This group has the lowest values for the last electricity bill, with 38% of individuals paying approximately US$12. **Group 3** comprised 73.2% of the individuals interviewed as responsible for the household, 77.70% were women, 38.4% were aged

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Tabela 3. Description of the groups as to categorical variables.

		Group 1		Group 2		Group 3		
		N	%	N	%	N	%	*p*[1]-value
Resp. by domicile	Yes	3,215	12.9%	6,925	21.9%	7,723	26.8%	<0.001
	No, is the spouse of the guardian	21,679	87.1%	24,733	78.1%	21,143	73.2%	
Gender	Female	6,326	25.4%	23,444	74.1%	22,431	77.7%	<0.001
	Male	18,568	74.6%	8,214	25.9%	6,435	22.3%	
Age group	Up to 18 years	4	0.0%	12	0.0%	280	1.0%	<0.001
	Between 18 and 25 years	343	1.4%	285	0.9%	5,031	17.4%	
	Between 26 and 35 years	1,911	7.7%	1,922	6.1%	11,079	38.4%	
	Between 36 and 45 years	4,641	18.6%	4,941	15.6%	8,182	28.3%	
	Between 46 and 55 years	7,176	28.8%	7,888	24.9%	3,316	11.5%	
	Between 56 and 65 years	6,188	24.9%	8,248	26.1%	897	3.1%	
	Over 65 years	4,631	18.6%	8,362	26.4%	81	0.3%	
Education level	Incomplete elementary school	4,940	19.8%	24,009	75.8%	1,374	4.8%	<0.001
	Complete elementary school	4,088	16.4%	5,291	16.7%	2,609	9.0%	
	Incomplete high school	1,776	7.1%	1,020	3.2%	3,108	10.8%	
	Complete high school	8,512	34.2%	1,291	4.1%	15,145	52.5%	
	Incomplete higher education	1,159	4.7%	26	0.1%	2,259	7.8%	
	Complete higher education	4,419	17.8%	21	0.1%	4,371	15.1%	
Annual family income	Less than US$ 1,992.45	52	0.2%	7,017	22.2%	2,143	7.4%	<0.001
	From US$ 1,992.45 to US$ 3,984.91	1,855	7.5%	15,121	47.8%	9,764	33.8%	
	From US$ 3,984.92 to US$ 9,962.26	15,999	64.3%	9,365	29.6%	15,229	52.8%	
	From US$ 9,962.27 to US$ 19,924.53	5,384	21.6%	155	0.5%	1,640	5.7%	
	From US$ 19,924.54 to US$ 29,886.79	1,168	4.7%	0	0.0%	87	0.3%	
	From US$ 29,886.80 to US$ 39,849.06	280	1.1%	0	0.0%	3	0.0%	
	More than US$ 39,849.06	156	0.6%	0	0.0%	0	0.0%	
Last account value	Less than US$ 11.32	1,725	6.9%	12,030	38.0%	4,134	14.3%	<0.001
	From US$ 11.32 to US$ 18.68	4,733	19.0%	8,296	26.2%	6,577	22.8%	
	From US$ 18.69 to US$ 28.30	4,729	19.0%	6,272	19.8%	12,140	42.1%	
	More than US$ 28.30	13,707	55.1%	5,060	16.0%	6,015	20.8%	

[1]Chi-square test

between 26 and 35 years, 52.8% had completed high school with an annual family income between US$ 3,974 and US$ 9,937 and the last amount on the energy bill between US$ 19.00 and US$ 28.95.

4.3. Description of the Theoretical Model

In the description of the theoretical model, the constructs **satisfaction**, **quality**, **value**, **loyalty**, and **trust** are tested. Questions from the ANEEL Consumer Satisfaction Index (IASC) are shown in Table 4 and in Figure 3 the distribution and discrepancies in the data of the observable variables that comprise each construct are presented.

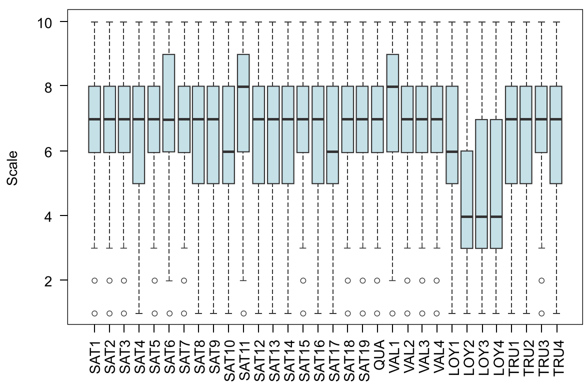

Figura 3. Constructs used and items evaluated.

Regarding the **quality** construct, the interviews indicated that QUA was as expected. The **satisfaction** construct tends to be within what is expected for the items: SAT1, SAT2, SAT3, SAT4, SAT5, SAT7, SAT8, SAT9, SAT10, SAT12, SAT13, SAT14, SAT15, SAT16, and SAT17. Items SAT6, SAT11, and SAT18 tend to be better than expected, and as for SAT19, there is a tendency that the quality is not ideal. In the **value** construct in items VAL2 and VAL3, there is a tendency that the

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Tabela 4. List of items of the ANEEL Index of Consumer Satisfaction.

Constructs	Items	Description
Trust	TRU1	The concessionaire/licensee very reliable.
	TRU2	I am sure the concessionaire/licensee cares about the interests of its customers.
	TRU3	The concessionaire/licensee very competent in providing its services to customers.
	TRU4	The concessionaire/licensee gives true/correct information to its customers.
Quality	QUA1	General assessment of the quality of services.
Value	VAL1	How do you evaluate the price of electricity?
	VAL2	Thinking about the facilities that energy brings to your life you would say the price is.
	VAL3	Thinking about the quality of the electricity supply as you rate the price paid.
	VAL4	Thinking about the aspects related to customer service how you evaluate the price paid.
Satisfaction	SAT1	Overall assessment of satisfaction with services.
	SAT2	Power supply without interruption, i.e. without power outage.
	SAT3	Power supply without variation in voltage, i.e. without alternating strong light with weak light.
	SAT4	Punctuality in the provision of services, that is, provide the service on the promised time/deadline.
	SAT5	Easy to contact the company (in person, by phone, via internet etc.)
	SAT6	Cordiality in service, i.e. education/courtesy of the staff who attend.
	SAT7	Advance warnings about power outages when there is a delay in payment of the account.
	SAT8	Reliability of the solutions given, that is, definitive solution of the problem presented.
	SAT9	Explanation about proper energy use, how to use efficiently, not to waste.
	SAT10	Security in the amount charged, that is, reliability in reading the consumption performed by the concessionaire/licensee are always correct account.
	SAT11	Ease of access to the locations/means of payment of the account, i.e. places for payment, direct debit etc.
	SAT12	Speed of power return when there is interruption/when light is lacking.
	SAT13	Quick responses to customer requests.
	SAT14	Early warnings about power outages when there is a need for repairs/repairs of the network.
	SAT15	Even care to all consumers, that is, there is no discrimination.
	SAT16	Information/guidance on the risks associated with the use of electricity.
	SAT17	Clarifications about their rights and duties, such as the right to safe energy and quality and the duty to pay the bill on time.
	SAT18	Detailing of the accounts, i.e. adequate/detailed information on the account.
	SAT19	Thinking about the quality of services, in general, you would say you are.
Loyalty	LOY1	What are the odds of changing your electricity company?
	LOY2	Suppose another company's price is better. What are the odds of changing your electricity company?
	LOY3	Assuming that the quality of another supplier's power supply is better. What are the odds of changing your electricity company?
	LOY4	Assuming customer service is better in another, What are the odds of changing your electricity company?

amount paid is neither cheap nor expensive, and about items VAL1 and VAL4, there is a tendency for the amount paid to be costly.

Some rating scales are built from items whose conceptual meaning is opposite to that of other items. The assigned value must be inverted to calculate the score in these cases. In this work, for the **loyalty** construct, an inversion is performed so that its items are in the same direction as the other constructs. Overall, the interviews indicate that LOY1 would depend on some factors; however, if there was another company with better LOY2, LOY3, and LOY4, the trend would be to switch from one utility company to another. Regarding the **trust** construct, items TRU1, TRU2, TRU3, and TRU4 tend to neither agree nor disagree. Table 5 summarizes the analyses of each construct.

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Tabela 5. Descriptive analysis of the constructs used and their items.

Construct	Item	Average	SD	CI - 95%[1]
Trust	TRU1	6.674	2.008	[6.661; 6.688]
	TRU2	6.485	2.110	[6.471; 6.498]
	TRU3	6.914	1.980	[6.902; 6.929]
	TRU4	6.704	2.031	[6.691; 6.718]
Quality	QUA	7.012	1.989	[6.999; 7.025]
Value	VAL1	7.668	1.897	[7.656; 7.681]
	VAL2	7.018	1.977	[7.005; 7.031]
	VAL3	7.019	1.925	[7.006; 7.032]
	VAL4	7.007	1.905	[6.994; 7.019]
Satisfaction	SAT1	6.958	2.157	[6.944; 6.973]
	SAT2	6.979	2.079	[6.965; 6.992]
	SAT3	6.884	2.084	[6.870; 6.898]
	SAT4	6.885	2.140	[6.872; 6.900]
	SAT5	6.921	2.212	[6.905; 6.935]
	SAT6	7.388	2.041	[7.375; 7.402]
	SAT7	6.837	2.231	[6.823; 6.853]
	SAT8	6.870	2.054	[6.857; 6.884]
	SAT9	6.594	2.236	[6.580; 6.608]
	SAT10	6.428	2.342	[6.414; 6.444]
	SAT11	7.459	2.052	[7.445; 7.473]
	SAT12	6.716	2.211	[6.701; 6.731]
	SAT13	6.697	2.117	[6.683; 6.712]
	SAT14	6.663	2.373	[6.647; 6.679]
	SAT15	7.049	2.045	[7.035; 7.062]
	SAT16	6.608	2.229	[6.593; 6.623]
	SAT17	6.476	2.238	[6.461; 6.490]
	SAT18	7.092	2.059	[7.078; 7.106]
	SAT19	6.549	1.988	[6.535; 6.564]
Loyalty	LOY1	6.032	2.300	[6.017; 6.047]
	LOY2	4.486	2.596	[4.469; 4.504]
	LOY3	4.453	2.627	[4.436; 4.473]
	LOY4	4.603	2.630	[4.587; 4.620]

[1]Bootstrap interval

4.4. Measurement Model

In the analysis of measurement models for structural equations modeling based on partial least squares (PLS-SEM), the convergent validity, discriminant validity, and reliability of the constructs were verified. Convergent validity guarantees that the indicators of a given construct are sufficiently correlated to measure the latent concept. Discriminant validity checks whether the constructs effectively measure different aspects of the phenomenon of interest. Reliability indicates the consistency of the measures in the idea to be measured. The results show that all items have factor loadings above 0.50; therefore, excluding items is unnecessary. For confidence intervals (CI – 95%), all weights are significant, indicating the importance of all items for forming indicators that represent the constructs. Table 6 shows the weights, factor loadings, and commonalities of the general measurement model for PLS-SEM. Table 7 and Table 8 show the analysis results of the convergent validity, discriminant validity, dimensionality, and reliability of the constructs of the general measurement model.

For the constructs, the Cronbach's alpha (CA) and composite reliability (CR) indices had values above 0.60, in which the required levels of reliability were reached for all constructs. Using Kaiser's criterion, all the constructs are one-dimensional. There is convergent validation in all constructs, as they all have an average variance extracted (AVE) greater than 0.40. According to Fornell's criterion [41], there is discriminant validation in all constructs, except for the **satisfaction** construct, given that the maximum shared variances (MSV) are lower than the respective AVE. Using cross-factor loadings [42], the **satisfaction** construct reaches the discriminant validation criterion, as the factor loadings of the items are higher than their respective maximum cross-factor loadings.

For the measurement model of structural equation modeling based on covariance (CB-SEM), it is necessary to test the normality of the data using the Shapiro-Wilk test (p-value < 0.05) [43]. In this analysis, the data are considered to be non-normal and proceed with the investigation in this approach. The method of Satorra and Bentler [44] was used to create estimators for the covariance

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Tabela 6. General measurement model for modeling structural equations based on partial least squares.

Construct	Item	Weight	CI - 95%[1]	FL[2]	Com.[3]
Trust	TRU1	0.273	[0.272; 0.273]	0.894	0.800
	TRU2	0.279	[0.278; 0.280]	0.911	0.831
	TRU3	0.280	[0.279; 0.282]	0.904	0.817
	TRU4	0.275	[0.274; 0.276]	0.904	0.817
Quality	QUA1	1.000	[1.000; 1.000]	1.000	1.000
Value	VAL1	0.265	[0.261; 0.269]	0.838	0.703
	VAL2	0.274	[0.270; 0.277]	0.911	0.831
	VAL3	0.290	[0.288; 0.293]	0.925	0.856
	VAL4	0.284	[0.280; 0.287]	0.914	0.835
Satisfaction	SAT1	0.077	[0.077; 0.078]	0.720	0.518
	SAT2	0.067	[0.066; 0.067]	0.755	0.570
	SAT3	0.065	[0.064; 0.066]	0.754	0.568
	SAT4	0.072	[0.071; 0.072]	0.811	0.658
	SAT5	0.066	[0.066; 0.066]	0.771	0.595
	SAT6	0.064	[0.064; 0.065]	0.765	0.585
	SAT7	0.062	[0.062; 0.063]	0.740	0.547
	SAT8	0.073	[0.073; 0.074]	0.831	0.690
	SAT9	0.067	[0.066; 0.067]	0.765	0.586
	SAT10	0.076	[0.076; 0.077]	0.771	0.594
	SAT11	0.053	[0.052; 0.054]	0.665	0.442
	SAT12	0.071	[0.070; 0.071]	0.796	0.633
	SAT13	0.075	[0.074; 0.075]	0.838	0.703
	SAT14	0.067	[0.067; 0.068]	0.758	0.574
	SAT15	0.069	[0.069; 0.069]	0.792	0.627
	SAT16	0.068	[0.068; 0.068]	0.766	0.587
	SAT17	0.070	[0.069; 0.070]	0.770	0.593
	SAT18	0.069	[0.069; 0.070]	0.762	0.581
	SAT19	0.076	[0.076; 0.077]	0.689	0.474
Loyalty	LOY1	0.348	[0.346; 0.351]	0.804	0.646
	LOY2	0.260	[0.258; 0.262]	0.894	0.800
	LOY3	0.266	[0.264; 0.268]	0.914	0.836
	LOY4	0.269	[0.267; 0.271]	0.908	0.824

[1]Confidence interval; [2]Factorial Loading; [3]Commonality

Tabela 7. Validation of the general measurement model for the modeling of structural equations based on partial least squares.

Construct	Item	CA[1]	CR[2]	Dim[3]	AVE[4]	MSV[5]
Trust	4	0.925	0.947	1	0.816	0.579
Quality	1	1.000	1.000	1	1.000	0.659
Value	4	0.919	0.943	1	0.806	0.176
Satisfaction	19	0.960	0.964	1	0.585	0.659
Loyalty	4	0.904	0.934	1	0.776	0.176

[1]Cronbach's alpha, [2]Composite Reliability, [3]Dimensionality, [4]Variance Extracted, [5]Maximum Share Variance.

structure in the confirmatory factor analysis. The dimensionality, reliability, and convergent validity were verified by analyzing the constructs' quality and validity. The Kaiser criterion [45] was used to verify the dimensionality of the constructs. To verify the convergent validity, the criterion proposed by Fornell and Larcker [41] was used, which indicates convergent validation when the AVE is greater than 50% [38] or 40% in the case of exploratory research [46]. To measure reliability, the CA and CR were used [47]. For discriminant validity, the criterion of Fornell and Larcker [41] is used, which guarantees discriminant validity when the AVE of a given construct is greater than the shared variance of this construct with the others.

The cross-factor loading method [42] was used to verify discriminant validation. According to Hair et al. [33], items with factor loadings less than 0.50 should be eliminated, as they do not contribute significantly to the formation of the latent variable; they impair the reach of the basic assumptions for validity and quality of the indicators calculated to represent the concept of interest. Table 9 shows the weights, factor loadings, and commonalities of the items of the constructs in general, indicating that all items have a significant weight and factor loadings above 0.50. The analysis of convergent validity,

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Tabela 8. Cross-factor loadings of the general measurement model for the modeling of structural equations based on partial least squares.

Construct	Item	FL[1]	Max (CFL)[2]
Trust	CON1	0.894	0.674
	CON2	0.911	0.683
	CON3	0.904	0.707
	CON4	0.904	0.685
Quality	QUA1	1.000	0.812
Value	VAL1	0.838	0.389
	VAL2	0.911	0.367
	VAL3	0.925	0.381
	VAL4	0.914	0.372
Satisfaction	SAT1	0.720	0.631
	SAT2	0.755	0.619
	SAT3	0.754	0.604
	SAT4	0.811	0.651
	SAT5	0.771	0.606
	SAT6	0.765	0.617
	SAT7	0.740	0.570
	SAT8	0.831	0.665
	SAT9	0.765	0.592
	SAT10	0.771	0.629
	SAT11	0.665	0.534
	SAT12	0.796	0.638
	SAT13	0.838	0.673
	SAT14	0.758	0.603
	SAT15	0.792	0.648
	SAT16	0.766	0.608
	SAT17	0.770	0.623
	SAT18	0.762	0.647
	SAT19	0.689	0.653
Loyalty	FID1	0.804	0.475
	FID2	0.894	0.392
	FID3	0.914	0.368
	FID4	0.908	0.372

[1]Factorial Loading; [2]Maximum Cross-factor Loading

discriminant validity, and reliability of the constructs of the general model of structural equation modeling based on covariance are shown in Table 10 and Table 11.

According to Kaiser's criterion, all constructs were one-dimensional, with convergent validation in all constructs. In all constructs, the CA and CR indices had values above 0.60, reaching reliability for all constructs. All constructs have an AVE greater than 0.40, and, according to the Fornell and Larcker criterion, there is discriminant validation in all constructs, except the **satisfaction** construct, given that the maximum shared variances were lower than the respective AVE. Using the method of cross-factor loadings, the **satisfaction** construct reached the discriminant validation criterion, as the factor loadings of the items were higher than their respective maximum cross-factor loadings.

4.5. Structural Model

To verify the quality of the adjustments of structural equation modeling based on partial least squares (PLS-SEM), the coefficient of determination (R^2) and goodness of fit (GoF) indices were used [48]. The GoF is the geometric mean of the AVEs of the constructs and R^2 of the model and varies from 0% to 100%. The value of R^2 for scale from 0% to 100% represents the extent to which the independent constructs explain the dependents. In contrast, values less than 25% represent weak explanatory capacity, values between 25% and 50% indicate moderate explanatory capacity, and values above 50% define the explanatory capacity [49]. The GoF in PLS-SEM cannot discriminate valid from invalid models, in addition to not being applied to models with formative constructs [50]. However, it allows for synthesizing the AVE and R^2 of the model in a single statistic. It is helpful for future comparisons of the adherence of different samples to the model. The results obtained for the structural model using PLS-SEM are presented in Table 12 and Figure 4.

With Table 12 and Figure 4 in hand, it is possible to carry out the analysis using the constructs. The **trust** construct explains 45.2% of the variability in the **quality** construct, resulting in moderate

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Tabela 9. General measurement model for the modeling of structural equations based on covariance.

Construct	Item	Weight	*p*-value	FL[1]	Com.[2]
Trust	TRU1	1.000	–	0.853	0.728
	TRU2	1.084	0.000	0.880	0.775
	TRU3	1.008	0.000	0.872	0.761
	TRU4	1.031	0.000	0.870	0.756
Quality	QUA1	1.000	–	1.000	1.000
Value	VAL1	1.000	–	0.749	0.561
	VAL2	1.217	0.000	0.875	0.765
	VAL3	1.247	0.000	0.920	0.846
	VAL4	1.205	0.000	0.898	0.807
Satisfaction	SAT1	1.000	–	0.700	0.491
	SAT2	1.015	0.000	0.737	0.543
	SAT3	1.014	0.000	0.735	0.540
	SAT4	1.134	0.000	0.801	0.641
	SAT5	1.110	0.000	0.758	0.574
	SAT6	1.015	0.000	0.752	0.565
	SAT7	1.068	0.000	0.723	0.523
	SAT8	1.118	0.000	0.822	0.676
	SAT9	1.106	0.000	0.748	0.559
	SAT10	1.168	0.000	0.754	0.568
	SAT11	0.876	0.000	0.645	0.416
	SAT12	1.148	0.000	0.785	0.616
	SAT13	1.167	0.000	0.833	0.694
	SAT14	1.167	0.000	0.743	0.552
	SAT15	1.057	0.000	0.781	0.610
	SAT16	1.105	0.000	0.749	0.561
	SAT17	1.117	0.000	0.754	0.569
	SAT18	1.018	0.000	0.747	0.558
	SAT19	0.883	0.000	0.671	0.451
Loyalty	LOY1	1.000	–	0.618	0.381
	LOY2	1.569	0.000	0.858	0.737
	LOY3	1.762	0.000	0.952	0.907
	LOY4	1.719	0.000	0.928	0.862

[1]Factorial Loading; [2]Commonality

Tabela 10. Validation of the general measurement model for structural equation modeling based on covariance.

Construct	Item	CA[1]	CR[2]	Dim[3]	AVE[4]	MSV[5]
Trust	4	0.925	0.925	1	0.755	0.681
Quality	1	1.000	1.000	1	1.000	0.694
Value	4	0.919	0.921	1	0.740	0.034
Satisfaction	19	0.960	0.961	1	0.561	0.694
Loyalty	4	0.906	0.910	1	0.704	0.187

[1]Cronbach's alpha, [2]Compound Reliability, [3]Dimensionality, [4]Variance Extracted, [5]Maximum Shared Variance.

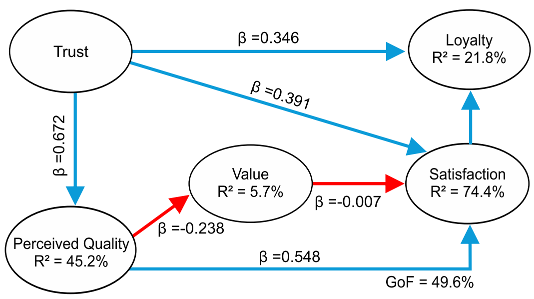

Figura 4. General structural model for modeling structural equations based on partial least squares.

explanatory power. The influence occurs with a *p*-value < 0.001 and positive with $\beta = 0.672$ [0.669; 0.676] of the **trust** construct over the **quality** construct, indicating that the greater the trust, the greater the quality. The **quality** construct explains 5.7% of the variability in the **value** construct, indicating a weak explanatory capacity. The **value** construct has an influence with a *p*-value < 0.001

Tabela 11. Cross-factor loadings of the general measurement model for structural equation modeling based on covariance.

Construct	Item	FL[1]	Max (SFL)[2]
Trust	CON1	0.853	0.682
	CON2	0.880	0.691
	CON3	0.872	0.708
	CON4	0.870	0.692
Quality	QUA1	1.000	0.829
Value	VAL1	0.749	0.372
	VAL2	0.875	0.338
	VAL3	0.920	0.351
	VAL4	0.898	0.344
Satisfaction	SAT1	0.700	0.637
	SAT2	0.737	0.621
	SAT3	0.735	0.611
	SAT4	0.801	0.662
	SAT5	0.758	0.633
	SAT6	0.752	0.644
	SAT7	0.723	0.599
	SAT8	0.822	0.671
	SAT9	0.748	0.612
	SAT10	0.754	0.652
	SAT11	0.645	0.579
	SAT12	0.785	0.650
	SAT13	0.833	0.680
	SAT14	0.743	0.628
	SAT15	0.781	0.666
	SAT16	0.749	0.622
	SAT17	0.754	0.633
	SAT18	0.747	0.665
	SAT19	0.671	0.657
Loyalty	FID1	0.618	0.480
	FID2	0.858	0.377
	FID3	0.952	0.375
	FID4	0.928	0.380

[1]Factorial Loading; [2]Maximum Shared Factor Load

Tabela 12. Quantitative description of the general structural model for structural equation modeling based on partial least squares.

Endogenous	Exogenous	β	SE (β^1)	CI – 95%[2]	p-value	R^2
Quality	Trust	0.672	0.003	[0.669; 0.676]	<0.001	45.2%
Value	Quality	-0.238	0.003	[-0.243; -0.230]	<0.001	5.7%
Satisfaction	Trust	0.391	0.002	[0.384; 0.397]	<0.001	74.4%
	Quality	0.548	0.002	[0.543; 0.554]	<0.001	
	Value	-0.007	0.002	[-0.010; -0.004]	<0.001	
Loyalty	Trust	0.346	0.005	[0.338; 0.356]	<0.001	21.8%
	Satisfaction	0.146	0.005	[0.136; 0.155]	<0.001	

[1]Standard Error; [2]confidence interval; GoF = 49,6%.

and negative with β = -0.238 [-0.243; -0.23] of the **quality** construct over the **value** construct, indicating that the higher the quality, the lower the perception that the amount paid in energy bills is high.

There is an influence of the **trust** construct on the **satisfaction** construct with p-value < 0.001 and positive with $\beta = 0.391$ [0.384; 0.397], indicating that the greater the trust, the greater the satisfaction. The influence measured between the **quality** construct on the **satisfaction** construct has a p-value $<$ 0.001 and positive with $\beta = 0.548$ [0.543; 0.554], indicating that the higher the quality, the greater the satisfaction. There is also the influence of the **value** construct on the **satisfaction** construct with p-value < 0.001 and negative with β = -0.007 [-0.01; -0.004], indicating that the higher the amount paid on energy bills, the lower the satisfaction. The **trust**, **quality**, and **value** constructs explain 74.4% of the variability of the **satisfaction** construct, indicating substantial explanatory capacity.

Regarding **loyalty**, there was a significant influence of **trust** with p-value < 0.001 and positive with $\beta = 0.346$ [0.338; 0.356]. Thus, the greater the **trust**, the greater the **loyalty**. There was also an influence of the **satisfaction** construct on the **loyalty** construct with p-value < 0.001 and positive with $\beta = 0.146$ [0.136; 0.155]. **Trust** and **satisfaction** were able to explain 21.8% of the variability

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in **loyalty**; that is, there was weak explanatory capacity. The model presented a GoF of 49.6% and the bootstrap confidence intervals agreed with the results obtained via the *p*-value, indicating greater validity of the results.

To verify the quality of fits in structural equation modeling based on covariance (CB-SEM), as well as in PLS-SEM, the R^2 was used. However, unlike PLS-SEM, CB-SEM still uses the comparative fit index (CFI), Tucker Lewis index (TLI), and mean squared error of approximation (RMSEA) in addition to the *p*-value to check if the RMSEA is statistically greater than 0.05. In this work, CFI and TLI are expected to be greater than 0.80 [51], and the RMSEA is less than 0.10 [52], ideally ≤ 0.05. The results of the structural model using CB-SEM are shown in Table 13 and shown in Figure 5.

Tabela 13. Quantitative description of the general structural model for structural equation modeling based on covariance.

Endogenous	Exogenous	β	SE (β^1)	CI − 95%^{2}	*p*-value	R^2
Quality	Trust	0.811	0.004	[0.803; 0.819]	<0.001	48.8%
Value	Quality	-0.175	0.003	[-0.181; -0.169]	<0.001	6.0%
Satisfaction	Trust	0.387	0.003	[0.381; 0.393]	<0.001	77.7%
	Quality	0.393	0.003	[0.387; 0.399]	<0.001	
	Value	0.001	0.002	[-0.003; 0.005]	0.509	
Loyalty	Trust	0.308	0.005	[0.298; 0.318]	<0.001	18.2%
	Satisfaction	0.063	0.006	[0.051; 0.075]	<0.001	

[1]Standard Error; [2]Confidence interval.

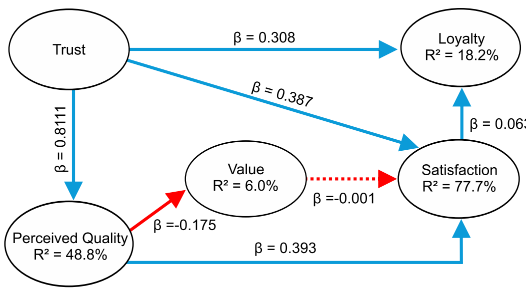

Figura 5. General structural model for the modeling of structural equations based on covariance.

Regarding **quality**, there was an influence of the **trust** construct with *p*-value < 0.001 and positive with $\beta = 0.811$. Therefore, the greater the **trust**, the greater is the **quality**. **Trust** explained 48.8% of the variability in **quality**, with moderate explanatory power. The **value** construct was influenced by the **quality** construct with *p*-value < 0.001 and negative with β = -0.175, so the higher the **quality**, the higher the **value**. The **quality** explained 6.0% of the variability in **value**, that is, there was a low explanatory capacity.

Regarding **satisfaction**, there was a significant and positive influence of the **trust** construct with *p*-value < 0.001 and $\beta = 0.387$; thus, the greater the **trust**, the greater the **satisfaction**. There was also a significant and positive influence of **quality** on **satisfaction**, with *p*-value < 0.001 and $\beta = 0.393$, so the higher the **quality**, the greater the **satisfaction**. Finally, there was no significant influence of **value** on **satisfaction**. The **trust**, **quality**, and **value** constructs together explained 77.7% of the variability in **satisfaction**, that is, there was substantial explanatory capacity.

For the **loyalty** construct, there was a significant influence of the **trust** construct with *p*-value < 0.001 and positive with $\beta = 0.308$, so the greater the **trust**, the greater the **loyalty**. Regarding **satisfaction** with **loyalty**, there was a significant difference with *p*-value < 0.001 and positive with $\beta = 0.063$, that is, the greater the **satisfaction**, the greater the **loyalty**. Finally, **trust** and **satisfaction** were able to explain 18.2% of the variability in **loyalty**, with weak explanatory capacity.

Table 14 shows the measures of the goodness of fit for the general CB-SEM model. The values indicate that the general model is satisfactory with values of CFI and TLI ≥ 0.80 and RMSEA ≤ 0.10, with *p*-value ≤ 0.05.

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Tabela 14. Result of the adjustment of the structural model for the modeling of structural equations based on covariance.

CFI	TLI	RMSEA	p-value
0.933	0.928	0.054	<0.001

4.6. Multigroup Analysis

To compare the relationships between the constructs using PLS-SEM, a multigroup analysis was performed in each group (**Group 1**, **Group 2**, and **Group 3**). Thus, models were adjusted for each group, and the results of these models were compared. Table 15 shows the p-values of the multigroup analysis for the weights of the measurement models per group. If the comparison between the weights of a given item has a significant difference, that is, p-value < 0.050 in any of the groups, there is evidence that the perception of that concept has changed between the groups.

Tabela 15. Weights of the multigroup analysis of the measurement model of structural equation modeling based on partial least squares.

Construct	Item	Group 1 x Group 2	Group 1 x Group 3	Group 2 x Group 3
Trust	CON1	<0.520	0.063	0.206
	CON2	0.013	0.000	0.085
	CON3	0.165	0.003	0.000
	CON4	<0.849	0.414	0.309
Value	VAL1	0.552	<0.467	0.811
	VAL2	0.384	0.029	0.114
	VAL3	0.109	0.006	0.000
	VAL4	0.032	0.028	0.000
Satisfaction	SAT1	0.078	0.004	0.000
	SAT2	0.394	0.170	0.026
	SAT3	0.413	0.984	0.441
	SAT4	0.230	0.191	0.011
	SAT5	0.431	0.414	0.080
	SAT6	0.012	0.697	0.008
	SAT7	0.425	0.254	0.657
	SAT8	0.070	0.000	0.000
	SAT9	0.350	0.001	0.000
	SAT10	0.886	0.001	0.001
	SAT11	0.084	0.883	0.132
	SAT12	0.412	0.223	0.029
	SAT13	0.002	0.003	0.000
	SAT14	0.401	0.682	0.736
	SAT15	0.003	0.000	0.080
	SAT16	0.934	0.000	0.000
	SAT17	0.454	0.000	0.000
	SAT18	0.131	0.000	0.000
	SAT19	0.314	0.009	0.000
Loyalty	FID1	0.068	0.001	0.000
	FID2	0.861	0.009	0.006
	FID3	0.737	0.042	0.007
	FID4	0.436	0.142	0.398

The analysis of convergent validity, discriminant validity, dimensionality, and reliability of the constructs in the measurement models of the groups are shown in Table 16 and Table 17. In the measurement models of the three groups, all constructs presented CA and/or CR values greater than 0.60, indicating the reliability of the models. All constructs were one-dimensional according to Kaiser's criterion [45] and all reached convergent validation, as the AVEs were above 0.40. The **trust**, **quality**, **value**, and **loyalty** constructs reached discriminant validation according to Fornell's criterion [41] for the three models, since the maximum shared variances were lower than the respective AVEs. However, the **satisfaction** construct did not reach discriminant validation by Fornell's criterion [41] in any of the groups. Still, there was discriminant validation of this construct in the three groups according to the criterion of factor loadings because the factor loadings of the items were greater than their respective maximum cross-factor loadings.

Tabela 16. Validation of measurement models for groups using structural equation modeling based on partial least squares.

	Construct	Item	CA[1]	CR[2]	Dim[3]	AVE[4]	MSV[5]
Group 1	Trust	4	0.928	0.948	1	0.822	0.587
	Quality	1	1.000	1.000	1	1.000	0.676
	Value	4	0.912	0.939	1	0.793	0.056
	Satisfaction	19	0.961	0.965	1	0.591	0.676
	Loyalty	4	0.903	0.933	1	0.773	0.206
Group 2	Trust	4	0.926	0.948	1	0.819	0.569
	Quality	1	1.000	1.000	1	1.000	0.646
	Value	4	0.932	0.951	1	0.830	0.048
	Satisfaction	19	0.962	0.965	1	0.593	0.646
	Loyalty	4	0.908	0.937	1	0.785	0.203
Group 3	Trust	4	0.918	0.942	1	0.803	0.567
	Quality	1	1.000	1.000	1	1.000	0.651
	Value	4	0.907	0.935	1	0.783	0.056
	Satisfaction	19	0.957	0.961	1	0.565	0.651
	Loyalty	4	0.894	0.928	1	0.756	0.191

[1]Cronbach's alpha, [2]Compound Reliability, [3]Dimensionality, [4]Variance Extracted, [5]Maximum Shared Variance.

Tabela 17. Cross-factor loadings of group models using structural equation modeling based on partial least squares.

Construct	Item	Group 1		Group 2		Group 3	
		FL[1]	Max (CFL)[2]	FL[1]	Max (CFL)[2]	FL[1]	Max (CFL)[2]
Trust	TRU1	0.898	0.679	0.895	0.671	0.887	0.661
	TRU2	0.911	0.685	0.915	0.682	0.904	0.668
	TRU3	0.908	0.717	0.905	0.697	0.896	0.699
	TRU4	0.909	0.697	0.904	0.680	0.897	0.670
Quality	QUA1	1.000	0.822	1.000	0.804	1.000	0.807
Value	VAL1	0.819	0.383	0.863	0.389	0.810	0.354
	VAL2	0.909	0.357	0.923	0.382	0.898	0.332
	VAL3	0.921	0.371	0.933	0.391	0.921	0.351
	VAL4	0.909	0.357	0.924	0.387	0.907	0.343
Satisfaction	SAT1	0.727	0.646	0.715	0.618	0.714	0.627
	SAT2	0.764	0.632	0.758	0.620	0.736	0.596
	SAT3	0.754	0.613	0.763	0.604	0.737	0.586
	SAT4	0.816	0.668	0.817	0.649	0.795	0.631
	SAT5	0.775	0.622	0.778	0.602	0.757	0.589
	SAT6	0.777	0.630	0.764	0.614	0.750	0.600
	SAT7	0.744	0.581	0.748	0.571	0.725	0.555
	SAT8	0.834	0.680	0.833	0.654	0.823	0.659
	SAT9	0.766	0.600	0.770	0.590	0.754	0.580
	SAT10	0.775	0.637	0.775	0.630	0.757	0.612
	SAT11	0.667	0.538	0.682	0.543	0.640	0.515
	SAT12	0.803	0.654	0.801	0.638	0.777	0.614
	SAT13	0.843	0.688	0.839	0.666	0.829	0.659
	SAT14	0.763	0.617	0.770	0.610	0.733	0.576
	SAT15	0.792	0.653	0.802	0.655	0.777	0.630
	SAT16	0.764	0.614	0.774	0.603	0.755	0.599
	SAT17	0.765	0.626	0.774	0.619	0.765	0.616
	SAT18	0.762	0.647	0.769	0.646	0.751	0.644
	SAT19	0.692	0.669	0.680	0.639	0.689	0.646
Loyalty	LOY1	0.807	0.473	0.807	0.470	0.799	0.460
	LOY2	0.891	0.386	0.898	0.391	0.884	0.364
	LOY3	0.911	0.365	0.920	0.367	0.899	0.335
	LOY4	0.905	0.370	0.914	0.373	0.892	0.341

[1]Factorial Loading; [2]Maximum Cross-Factor Loading

Table 18, Table 19, and Table 20 display the results, Figure 6, Figure 7, and Figure 8 present the structural models and Table 21 displays the p-values of the multigroup analysis for the coefficients, all for each group using PLS-SEM.

The multigroup analysis indicated that there was no significant difference in the influence of **trust** on **quality** between the three groups (p-value > 0.050). However, there was a significant difference in the influence of **quality** on **value** with p-value$= 0,049$ in the comparison between **Group 2** and

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Tabela 18. Structural model for **Group 1** using structural equation modeling based on partial least squares.

Endogenous	Exogenous	β	SE (β^1)	CI – 95%[2]	p-value	R^2
Quality	Trust	0.675	0.005	[0.667; 0.683]	0.000	45.5%
Value	Quality	-0.236	0.006	[-0.249; -0.223]	0.000	5.6%
Satisfaction	Trust	0.388	0.004	[0.376; 0.397]	0.000	75.8%
	Quality	0.559	0.004	[0.551; 0.571]	0.000	
	Value	-0.004	0.003	[-0.010; 0.001]	0.172	
Loyalty	Trust	0.345	0.009	[0.327; 0.360]	0.000	21.5%
	Satisfaction	0.143	0.009	[0.127; 0.162]	0.000	

[1]Standard Error; [2]Confidence interval; GoF = 49.9%.

Tabela 19. Structural model for **Group 2** using structural equation modeling based on partial least squares.

Endogenous	Exogenous	β	SE (β^1)	CI – 95%[2]	p-value	R^2
Quality	Trust	0.665	0.004	[0.657; 0.673]	0.000	44.3%
Value	Quality	-0.220	0.005	[-0.230; -0.210]	0.000	4.8%
Satisfaction	Trust	0.391	0.004	[0.382; 0.401]	0.000	73.3%
	Quality	0.542	0.004	[0.532; 0.549]	0.000	
	Value	-0.011	0.003	[-0.017; -0.006]	0.000	
Loyalty	Trust	0.341	0.008	[0.326; 0.356]	0.000	21.2%
	Satisfaction	0.145	0.008	[0.127; 0.161]	0.000	

[1]Standard Error; [2]Confidence interval; GoF = 49.3%.

Tabela 20. Structural model for **Group 3** using structural equation modeling based on partial least squares.

Endogenous	Exogenous	β	SE (β^1)	CI – 95%[2]	p-value	R^2
Quality	Trust	0.665	0.004	[0.659; 0.672]	0.000	44.2%
Value	Quality	-0.236	0.006	[-0.248; -0.225]	0.000	5.6%
Satisfaction	Trust	0.387	0.004	[0.376; 0.396]	0.000	73.6%
	Quality	0.549	0.004	[0.540; 0.560]	0.000	
	Value	-0.004	0.003	[-0.011; 0.002]	0.173	
Loyalty	Trust	0.330	0.008	[0.314; 0.345]	0.000	20.0%
	Satisfaction	0.141	0.008	[0.123; 0.158]	0.000	

[1]Standard Error; [2]Confidence interval; GoF = 48.2%.

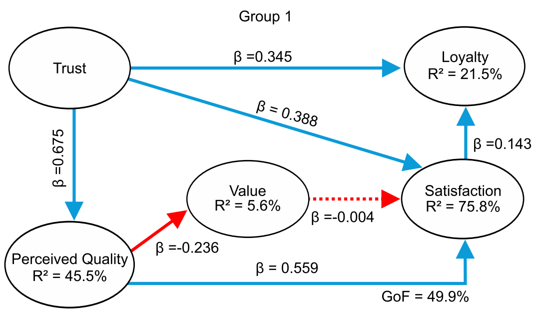

Figura 6. Group 1 structural model using structural equation modeling based on partial least squares.

Group 3, in which the strength of the influence of quality on the value construct was lower in **Group 3**, as follows: **Group 2** with β = -0.220 and **Group 3** with β = -0.236. Regarding **trust** in **satisfaction** constructs, there was no significant difference in influence between groups with a p-value > 0.050. Regarding the **quality** over **satisfaction** constructs, there was a significant difference (p-value = 0.002) in the comparison between **Group 1** and **Group 2**, with the strength of influence of quality on **satisfaction** being higher in **Group 1** ($\beta = 0.559$) and **Group 2** ($\beta = 0.542$).

There was also no significant difference in the influence of **trust** on **loyalty** between the three groups, with a p-value > 0.050 and finally, there was no significant difference in the influence of

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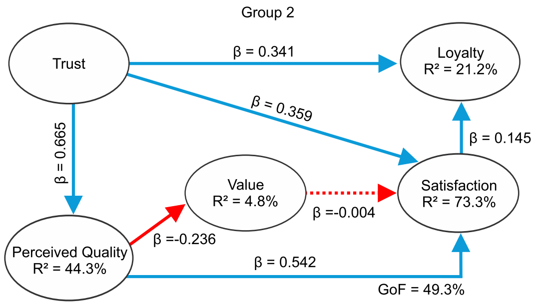

Figura 7. Group 2 structural model using structural equation modeling based on partial least squares.

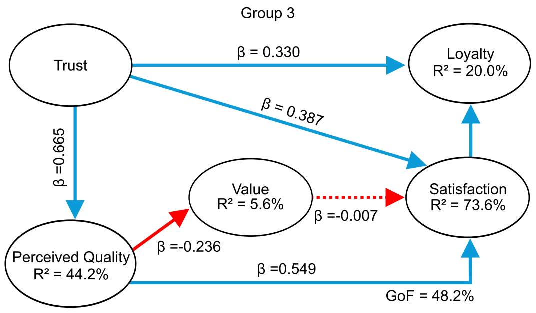

Figura 8. Group 3 structural model using structural equation modeling based on partial least squares.

Tabela 21. Coefficients of the structural model by Group using structural equation modeling based on partial least squares.

Endogenous	**Exogenous**	**Group 1 x Group 2**	**Group 1 x Group 3**	**Group 2 x Group 3**
Quality	Trust	0.128	0.111	0.914
Value	Quality	0.052	0.961	0.049
	Trust	0.579	0.848	0.440
Satisfaction	Quality	0.002	0.094	0.163
	Value	0.139	0.973	0.121
Loyalty	Trust	0.721	0.227	0.356
	Satisfaction	0.868	0.877	0.734

satisfaction on **loyalty** between the three groups (p-value > 0.050). As there were significant different weights between the years analyzed (2014 – 2018) for all constructs, except for the quality construct, the significant differences between the weights may have caused the significant difference between the structural coefficients. The models presented GoFs equal to 49.9%, 49.3% and 48.2% for **Group 1**, **Group 2**, and **Group 3**, respectively.

The results of the models of the three groups were compared using metric equivalence analysis. A multigroup analysis was also performed using structural equation modeling based on covariance (CB-SEM) in the three groups. The analysis of convergent validity, discriminant validity, dimensionality and reliability of the constructs of the measurement models of the groups using CB-SEM are shown in Table 22 and Table 23.

In the three measurement models, all constructs had CA and/or CR value ≥ 0.60, indicating the reliability of the models. According to Kaiser's criterion, all constructs were one-dimensional, and all reached convergent validation, as AVE was ≥ 0.40. The **trust**, **quality**, **value**, and **loyalty** constructs reached discriminant validation according to the Fornell and Larcker criteria in the group models, since the maximum shared variances were lower than the respective AVEs. However, the

Tabela 22. Validation of measurement models for groups using structural equation modeling based on covariance.

	Construct	Item	CA[1]	CR[2]	Dim[3]	AVE[4]	MSV[5]
Group 1	Trust	4	0.927	0.926	1	0.758	0.679
	Quality	1	1.000	1.000	1	1.000	0.697
	Value	4	0.913	0.932	1	0.773	0.043
	Satisfaction	19	0.961	0.962	1	0.569	0.697
	Loyalty	4	0.905	0.915	1	0.715	0.184
Group 2	Trust	4	0.926	0.926	1	0.758	0.668
	Quality	1	1.000	1.000	1	1.000	0.659
	Value	4	0.932	0.932	1	0.773	0.032
	Satisfaction	19	0.962	0.962	1	0.569	0.668
	Loyalty	4	0.911	0.915	1	0.715	0.177
Group 3	Trust	4	0.918	0.918	1	0.737	0.680
	Quality	1	1.000	1.000	1	1.000	0.687
	Value	4	0.907	0.909	1	0.709	0.046
	Satisfaction	19	0.957	0.957	1	0.540	0.687
	Loyalty	4	0.896	0.900	1	0.680	0.166

[1]Cronbach's alpha, [2]Compound Reliability, [3]Dimensionality, [4]Variance Extracted , [5]Maximum Shared Variance.

Tabela 23. Cross-factor loadings of group models using structural equation modeling based on partial least squares.

Construct	**Item**	**Group 1**		**Group 2**		**Group 3**	
		FL[1]	**Max (CFL)[2]**	**FL[1]**	**Max (CFL)[2]**	**FL[1]**	**Max (CFL)[2]**
Trust	TRU1	0.857	0.682	0.855	0.679	0.842	0.670
	TRU2	0.878	0.688	0.886	0.688	0.869	0.678
	TRU3	0.879	0.714	0.874	0.696	0.862	0.703
	TRU4	0.878	0.699	0.869	0.684	0.860	0.680
Quality	QUA1	1.000	0.835	1.000	0.822	1.000	0.827
Value	VAL1	0.719	0.369	0.790	0.369	0.710	0.340
	VAL2	0.870	0.332	0.892	0.352	0.855	0.302
	VAL3	0.917	0.343	0.925	0.363	0.915	0.319
	VAL4	0.893	0.331	0.910	0.359	0.887	0.312
Satisfaction	SAT1	0.709	0.648	0.692	0.626	0.695	0.629
	SAT2	0.746	0.623	0.740	0.614	0.717	0.597
	SAT3	0.736	0.613	0.745	0.599	0.718	0.594
	SAT4	0.807	0.677	0.806	0.650	0.784	0.634
	SAT5	0.762	0.625	0.764	0.614	0.742	0.600
	SAT6	0.764	0.628	0.751	0.620	0.736	0.606
	SAT7	0.728	0.597	0.732	0.594	0.706	0.569
	SAT8	0.826	0.678	0.824	0.661	0.814	0.651
	SAT9	0.748	0.610	0.754	0.614	0.736	0.598
	SAT10	0.758	0.655	0.757	0.648	0.738	0.639
	SAT11	0.648	0.573	0.664	0.581	0.620	0.540
	SAT12	0.794	0.659	0.791	0.646	0.764	0.631
	SAT13	0.838	0.688	0.834	0.675	0.822	0.671
	SAT14	0.749	0.621	0.757	0.631	0.716	0.595
	SAT15	0.780	0.665	0.794	0.665	0.764	0.650
	SAT16	0.746	0.619	0.759	0.626	0.737	0.612
	SAT17	0.748	0.628	0.760	0.629	0.748	0.637
	SAT18	0.746	0.657	0.755	0.667	0.736	0.663
	SAT19	0.676	0.664	0.660	0.646	0.672	0.653
Loyalty	LOY1	0.618	0.474	0.626	0.478	0.592	0.456
	LOY2	0.849	0.372	0.867	0.381	0.845	0.351
	LOY3	0.951	0.370	0.957	0.371	0.945	0.340
	LOY4	0.928	0.376	0.934	0.374	0.917	0.347

[1]Factorial Loading; [2]Maximum Cross-factor Loading

satisfaction construct did not reach discriminant validation by the Fornell and Larcker criteria in any of the groups. According to the factor loadings criterion, there was discriminant validation of the **satisfaction** construct in the three groups since the factor loadings of the items were greater than their respective maximum cross-factor loadings.

Structural models per group using CB-SEM with equal factor loadings (with restriction) × different factor loadings (without restriction) are displayed in Table 24, Table 25 and Table 26, and Figure 10 and Figure 9 show the models.

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Tabela 24. Structural model for **Group 1** using structural equation modeling based on covariance.

Endogenous	Exogenous	No restriction				
		β	SE (β[1])	CI − 95%[2]	p-value	R^2
Quality	Trust	0.796	0.007	[0.782; 0.810]	<0.001	49.1%
Value	Quality	-0.160	0.004	[-0.168; -0.152]	<0.001	5.9%
Satisfaction	Trust	0.379	0.006	[0.367; 0.391]	<0.001	79.0%
	Quality	0.410	0.005	[0.40; 0.420]	<0.001	
	Value	0.004	0.004	[-0.004; 0.012]	0.303	
Loyalty	Trust	0.313	0.010	[0.293; 0.333]	<0.001	17.8%
	Satisfaction	0.060	0.011	[0.038; 0.082]	<0.001	
		With restriction				
Quality	Trust	0.793	0.006	[0.781; 0.805]	<0.001	49.1%
Value	Quality	-0.169	0.005	[-0.179; -0.159]	<0.001	5.9%
Satisfaction	Trust	0.376	0.006	[0.364; 0.388]	<0.001	79.0%
	Quality	0.408	0.005	[0.398; 0.418]	<0.001	
	Value	0.004	0.004	[-0.004; 0.012]	0.297	
Loyalty	Trust	0.303	0.010	[0.283; 0.323]	<0.001	17.8%
	Satisfaction	0.058	0.011	[0.036; 0.080]	<0.001	

[1]Standard Error; [2]Bootstrap interval.

Tabela 25. Structural model for **Group 2** using structural equation modeling based on covariance.

Endogenous	Exogenous	No restriction				
		β	SE (β[1])	CI − 95%[2]	p-value	R^2
Quality	Trust	0.817	0.006	[0.805; 0.829]	<0.001	47.6%
Value	Quality	-0.176	0.005	[-0.186; -0.166]	<0.001	5.1%
Satisfaction	Trust	0.395	0.006	[0.383; 0.407]	<0.001	76.3%
	Quality	0.392	0.005	[0.382; 0.402]	<0.001	
	Value	-0.001	0.003	[-0.007; 0.005]	0.668	
Loyalty	Trust	0.300	0.009	[0.282; 0.318]	<0.001	17.6%
	Satisfaction	0.070	0.009	[0.052; 0.088]	<0.001	
		With restriction				
Quality	Trust	0.819	0.006	[0.807; 0.831]	<0.001	47.7%
Value	Quality	-0.165	0.004	[-0.173; -0.157]	<0.001	5.1%
Satisfaction	Trust	0.392	0.005	[0.382; 0.402]	<0.001	76.4%
	Quality	0.388	0.005	[0.378; 0.398]	<0.001	
	Value	-0.001	0.003	[-0.007; 0.005]	0.662	
Loyalty	Trust	0.308	0.009	[0.290; 0.326]	<0.001	17.6%
	Satisfaction	0.072	0.009	[0.054; 0.09]	<0.001	

[1]Standard Error; [2]Bootstrap interval.

Tabela 26. Structural model for **Group 3** using structural equation modeling based on covariance.

Endogenous	Exogenous	No restriction				
		β	SE (β[1])	CI − 95%[2]	p-value	R^2
Quality	Trust	0.812	0.007	[0.798; 0.826]	<0.001	48.1%
Value	Quality	-0.162	0.004	[-0.170; -0.154]	<0.001	6.0%
Satisfaction	Trust	0.382	0.006	[0.370; 0.394]	<0.001	77.3%
	Quality	0.385	0.005	[0.375; 0.395]	<0.001	
	Value	0.004	0.004	[-0.004; 0.012]	0.368	
Loyalty	Trust	0.280	0.009	[0.262; 0.298]	<0.001	15.9%
	Satisfaction	0.049	0.010	[0.029; 0.069]	<0.001	
		With restriction				
Quality	Trust	0.811	0.006	[0.799; 0.823]	<0.001	48.1%
Value	Quality	-0.170	0.004	[-0.178; -0.162]	<0.001	6.0%
Satisfaction	Trust	0.387	0.005	[0.377; 0.397]	<0.001	77.3%
	Quality	0.390	0.005	[0.380; 0.40]	<0.001	
	Value	0.003	0.004	[-0.005; 0.011]	0.358	
Loyalty	Trust	0.280	0.009	[0.262; 0.298]	<0.001	15.9%
	Satisfaction	0.048	0.010	[0.028; 0.068]	<0.001	

[1]Standard Error; [2]Bootstrap interval.

Regarding the **quality** construct, there was a significant and positive influence of **trust** for all models **with restriction** on factorial loadings: **Group 1** with $\beta = 0.793$, **Group 2** with $\beta = 0.819$, **Group 3** with $\beta = 0.811$. There was also a significant and positive influence of **trust** for all models with **no restriction** on factor loadings: **Group 1** with $\beta = 0.796$, **Group 2** with $\beta = 0.817$, **Group 3** with $\beta = 0.812$. The p-value was < 0.001 for all groups evaluated with and without restriction. Overall,

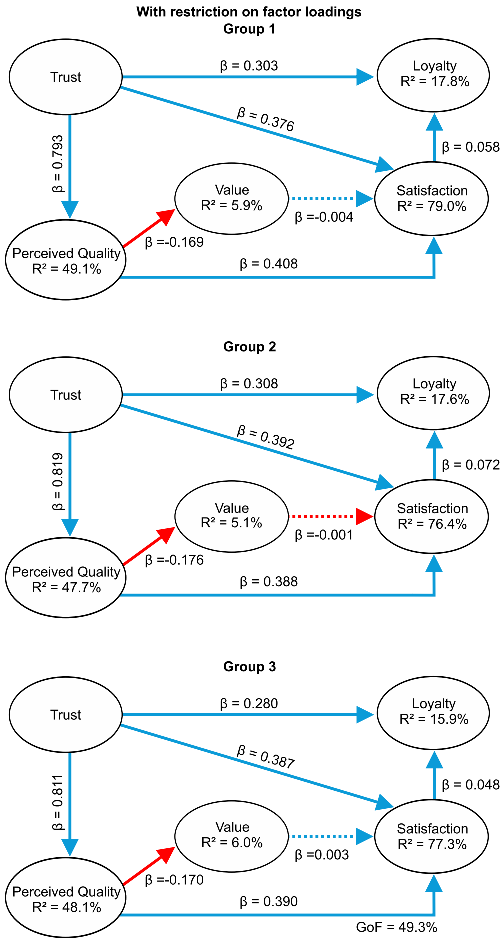

Figura 9. Structural model of **with restriction** Groups using structural equation modeling based on covariance.

quality variability was best explained by **trust** in **Group 1** with 49.1%. For the **value** construct, there was a significant and negative influence of **quality** on all models **with restriction** on factor loadings: **Group 1** with β = -0.169, **Group 2** with β = -0.165, **Group 3** with β = -0.170 and **without restriction** on factor loadings: Group 1 with β = -0.160, Group 2 with β = -0.176, Group 3 with β = -0.162. A p-value< 0.001 for all groups evaluated with and without restriction. Overall, the variability of the **value** was better explained by the **quality** in **Group 3** with 6.0%.

Regarding the **satisfaction** construct, there was a significant and positive influence of **trust** in all models: **with restriction** on factor loadings: **Group 1** with $\beta = 0.376$, **Group 2** with $\beta = 0.392$, Group 3 with $\beta = 0.387$. **With restriction** on factor loadings: **Group 1** with $\beta = 0.379$, **Group 2** with $\beta = 0.395$, **Group 3** with $\beta = 0.382$. In the **quality** construct, there was a significant and positive influence on **satisfaction** for all models **with restriction** on factor loadings: **Group 1** with $\beta = 0.408$, **Group 2** with $\beta = 0.388$, **Group 3** with $\beta = 0.390$ and **no restriction** on factor loadings: **Group 1** with $\beta = 0.410$, **Group 2** with $\beta = 0.392$, **Group 3** with $\beta = 0.385$. The variability in **satisfaction** was best explained by **trust**, **quality**, and **value** in **Group 1** with 79.0%.

Regarding the **loyalty** construct, there was a significant and positive influence of **trust** in all models: **with restriction** on factor loadings: **Group 1** with $\beta = 0.303$, **Group 2** with $\beta = 0.308$, **Group 3** with $\beta = 0.280$, and **no restriction** on factor loadings: **Group 1** with $\beta = 0.313$, **Group 2** with $\beta = 0.300$, **Group 3** with $\beta = 0.280$. There was a significant and positive influence of **satisfaction** on **loyalty** among all models **with restriction** on factor loadings: **Group 1** with $\beta = 0.058$, **Group 2**

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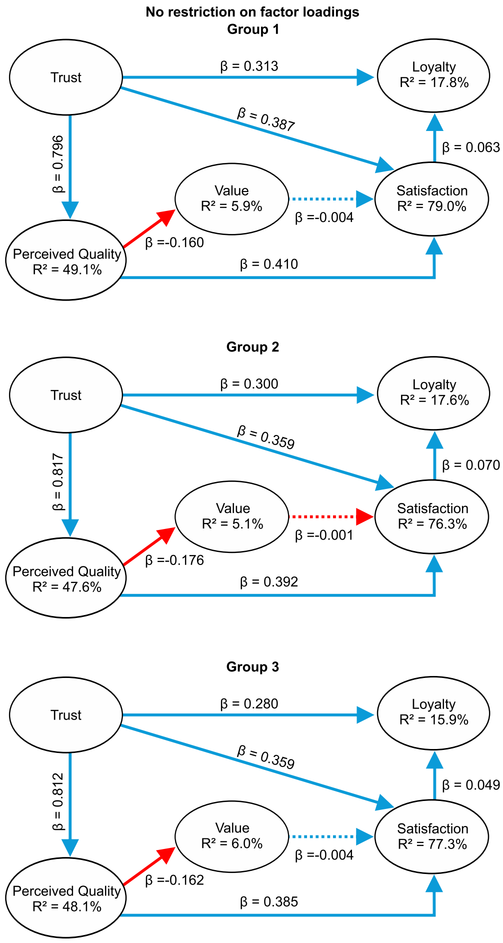

Figura 10. Structural model of **no restriction** Groups using structural equation modeling based on covariance.

with $\beta = 0.072$, **Group 3** with $\beta = 0.048$, and without restriction on factor loadings: **Group 1** with $\beta = 0.060$, **Group 2** with $\beta = 0.070$, **Group 3** with $\beta = 0.049$. Overall, the variability of **loyalty** was best explained by **trust** and **satisfaction** in **Group 1** with 17.8%.

The results for the three groups were similar between the models **with** and **without restriction** in factor loadings. The adjustments with total restriction of equality in the factor loading and later with the total restriction of equality in the factor loadings and intercepts are shown in Table 27. Thus enabling, based on the difference in the χ^2 statistic and the degrees of freedom of the nested models, to test the metric and scalar equivalence through cluster analysis. Metric non-equivalence implies that depending on the group, the way of interpreting and using the scale is different, while scalar non-equivalence implies that the importance attributed to the constructs varies from group to group; that is, there are differences between groups in how to quantify the constructs.

Tabela 27. Analysis of metric and scalar equivalence.

Restriction	χ^2	DF	CFI	TLI	RMSEA	*p*-value
–	175,750.800	1,374.000	0.932	0.926	0.054	–
Factor Loads	176,331.700	1,428.000	0.931	0.928	0.053	<0.001
Factor Loads + Intercepts	177,771.000	1,482.000	0.929	0.929	0.053	<0.001

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From the results shown in Table 27, it can be observed that there was no metric or scalar equivalence between the groups because p-value ≤ 0.001, and RMSEA < 0.05. Thus, the interpretation of the scales was different between the groups, and the importance attributed to the constructs varied from group to group. The quality measures of the adjustments did not change even with the restrictions of the factor loadings and intercepts; that is, the models presented similar adjustments. Table 28 shows the quality measures of the fit of the models by a group with and without restriction using structural equation modeling based on covariance.

Tabela 28. Metric and scalar equivalence for groups.

Mode	CFI	TLI	RMSEA	p-value
No restriction (Yearly)	0.932	0.926	0.054	0.000
With restriction (Yearly)	0.931	0.928	0.053	0.000
Group 1	0.926	0.920	0.056	0.000
Group 2	0.943	0.938	0.050	0.000
Group 3	0.924	0.917	0.056	0.000

From Table 28, all models had CFI > 0.8, TLI > 0.8, RMSEA < 0.1 and p-value < 0.05, the latter being significant (the indicated values are reference values). Thus, all models had satisfactory adjustments and, even demonstrated in Table 27 and Table 28, that the factor loadings are different between the groups, and the model with the same factor loadings showed adjustment as much as the model with the different factor loadings.

4.7. Comparison Between Structural Equation Modeling Based on Partial Least Squares and Based on Covariance

There are several methods for estimating convergent validity, including factorial load evaluation. The high factorial load indicates that they converge to a common point, that is, there is convergent validity. The literature suggests that the factorial load can be $\leq 0,5$, but the ideal is > 0.5. If a given item displays a value < 0.5, it becomes a strong candidate to leave the factorial model. From Table 8 and Table 11, all item values have factorial load > 0.5, not needing to exclude any item for structural equation modeling based on partial least squares (PLS-SEM) and for structural equation modeling based on covariance (CB-SEM). The comparative analyses of convergent validity, discriminant validity, and reliability of the constructs for the measurement models of the PLS-SEM and CB-SEM are shown in Table 29 and Table 30.

Tabela 29. Comparison of measurement models.

	Construct	CR[1]	AVE[2]	MSV[3]
PLS-SEM	Trust	0.947	0.816	0.579
	Quality	1.000	1.000	0.659
	Value	0.943	0.806	0.176
	Satisfaction	0.964	0.585	0.659
	Loyalty	0.934	0.776	0.176
CB-SEM	Trust	0.925	0.755	0.681
	Quality	1.000	1.000	0.694
	Value	0.921	0.740	0.034
	Satisfaction	0.961	0.561	0.694
	Loyalty	0.910	0.704	0.187

[1]Compound Reliability, [2]Variance Extracted,
[3]Maximum Shared Variance.

According to Fornell's criterio [41], when evaluating the PLS-SEM and CB-SEM methods, there is discriminant validation in all constructs, except the **satisfaction** construct, given that the maximum shared variances (MSV) are lower than the respective AVE. Using the cross-factor loading method [42], the **satisfaction** construct reaches the discriminant validation criterion, as the factorial load of the items is higher than their respective maximum cross-factor loadings. In addition, from the comparison between the AVE of the constructs by applying PLS-SEM and CB-SEM, Table 29 shows that the

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Tabela 30. Comparison of measurement models through factorial loads.

	Construct	Mean FL[1]	Mean Max (FLC.)[2]
PLS-SEM	Trust	0.903	0.687
	Quality	1.000	0.812
	Value	0.897	0.377
	Satisfaction	0.764	0.622
	Loyalty	0.880	0.402
CB-SEM	Trust	0.869	0.693
	Quality	1.000	0.829
	Value	0.861	0.351
	Satisfaction	0.749	0.638
	Loyalty	0.839	0.403

[1]Factorial Load, [2]Maximum Cross-factor Loading.

PLS-SEM obtained better results than the CB-SEM, considering that its constructs **trust**, **value**, **satisfaction**, and **loyalty** achieved superior values. As the average variance extracted (AVE) is an indicator associated with the quality of the measure, the application of the structural model from the PLS-SEM generates more consistent results.

From the comparison between the averages of the factorial load of the constructs in the application of the PLS-SEM and the CB-SEM, it is also possible to observe in Table 30 that the PLS-SEM obtained better results than the CB-SEM, since its constructs **trust**, **value**, **satisfaction**, and **loyalty** achieved superior values. Factorial load indicates the amount of a given factor that explains a given variable. The application of the structural model based on PLS-SEM generates better results. Another measure is the AVE, which checks the proportion of variance of items by the construct to which they belong. Thus, as in the evaluation of factorial load, the model is considered valid when AVE $\geq 0,4$. Therefore, in Table 29 there is convergent validation in all constructs, whether using PLS-SEM or CB-SEM, as they all have AVE $\geq 0,4$.

To confirm the convergent validity, the composite reliability is usually evaluated, which assesses the adequate internal consistency for the PLS-SEM as it prioritizes the variables according to their reliability. As shown in Table 29, the constructs had CR $\geq 0,90$, for both PLS-SEM and CB-SEM, with the required levels being CR $\geq 0,60$. From the comparison between the CR of the constructs by applying the PLS-SEM and CB-SEM, it is also possible to observe in Table 29 that PLS-SEM obtained better results than CB-SEM.

When comparing the construct's composite reliability (CR) by applying PLS-SEM and CB-SEM, we observed that the **trust**, **value**, **satisfaction**, and **loyalty** constructs of the PLS-SEM reached better values. As composite reliability (CR) is an indicator associated with the quality of the measure, the application of the structural model based on PLS-SEM generates better results. In Table 29 and Table 30, construct **quality** for having a single indicator is: i) CR $= 1$, ii) AVE $= 1$, and iii) factor loading $= 1$ for both structural equation models. The comparative results of the general structural model are listed in Table 31.

Tabela 31. Comparison of structural models.

Endogenous	Exogenous	β		R^2	
		PLS-SEM	CB-SEM	PLS-SEM	CB-SEM
Quality	Trust	0.672	0.811	45.2%	48.8%
Value	Quality	-0.238	-0.175	5.7%	6.0%
Satisfaction	Trust	0.391	0.387	74.4%	77.7%
	Quality	0.548	0.393		
	Value	-0.007	0.001		
Loyalty	Trust	0.346	0.308	21.8%	18.2%
	Satisfaction	0.146	0.063		

The **trust** construct has a greater influence on the **quality** construct and presents a higher R^2 in CB-SEM than in PLS-SEM. In CB-SEM, the value construct exerts a greater influence on the **quality** construct and presents a higher R^2 in the PLS-SEM. On the other hand, in PLS-SEM, there is a greater influence of the **trust**, **quality**, and **value** constructs on the **satisfaction** construct than in

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CB-SEM. Still, in CB-SEM, the quality of the model's fit is better because of the higher R^2 compared to PLS-SEM. Finally, the **trust** construct and the **satisfaction** construct exert greater influence on the **loyalty** construct and present a higher R^2 in PLS-SEM than in CB-SEM. Comparative analyses of convergent validity, discriminant validity, and reliability of the constructs in the measurement models of the groups are shown in Table 32 and Table 33.

Tabela 32. Comparison of group measurement models.

	Construct	CR[1]	AVE[2]	MSV[3]
Group 1 PLS-SEM	Trust	0.948	0.822	0.587
	Quality	1.000	1.000	0.676
	Value	0.939	0.793	0.056
	Satisfaction	0.965	0.591	0.676
	Loyalty	0.933	0.773	0.206
Group 2 PLS-SEM	Trust	0.948	0.819	0.569
	Quality	1.000	1.000	0.646
	Value	0.951	0.830	0.048
	Satisfaction	0.965	0.593	0.646
	Loyalty	0.937	0.785	0.203
Group 3 PLS-SEM	Trust	0.942	0.803	0.567
	Quality	1.000	1.000	0.651
	Value	0.935	0.783	0.056
	Satisfaction	0.961	0.565	0.651
	Loyalty	0.928	0.756	0.191
Group 1 CB-SEM	Trust	0.926	0.758	0.679
	Quality	1.000	1.000	0.697
	Value	0.932	0.773	0.043
	Satisfaction	0.962	0.569	0.697
	Loyalty	0.915	0.715	0.184
Group 2 CB-SEM	Trust	0.926	0.758	0.668
	Quality	1.000	1.000	0.659
	Value	0.932	0.773	0.032
	Satisfaction	0.962	0.569	0.668
	Loyalty	0.915	0.715	0.177
Group 3 CB-SEM	Trust	0.918	0.737	0.680
	Quality	1.000	1.000	0.687
	Value	0.909	0.709	0.046
	Satisfaction	0.957	0.540	0.687
	Loyalty	0.900	0.680	0.166

[1]Compound Reliability, [2]Variance Extracted,
[3]Maximum Shared Variance.

In Table 32, there is convergent validation in all constructs, whether using PLS-SEM or CB-SEM for all groups (**Group 1**, **Group 2**, **Group 3**), since all have AVE ≥ 0.40. According to Fornell's criterion [41], when evaluating the PLS-SEM and CB-SEM methods show discriminant validity in all constructs, except the **satisfaction** construct, given that MSV $<$ AVE. From the comparison between the averages of the factor loadings of the constructs by applying PLS-SEM and CB-SEM, it is possible to observe in Table 33 that the PLS-SEM obtained better results than the CB-SEM in all groups. This occurred because the constructs achieved better values for PLS-SEM than CB-SEM.

Using the method of cross-factor loadings [42], the satisfaction construct reached the discriminant validation criterion because the factor loadings of the items were higher than their respective maximum cross-factor loadings in all groups. In addition, based on the comparison between the AVEs of the constructs by applying PLS-SEM and CB-SEM, it can be observed in Table 32 that the PLS-SEM obtained better results than the CB-SEM for all groups. From Table 32, it is observed that the index CR ≥ 0.90 for constructs using PLS-SEM or CB-SEM in all groups. From the comparison between the CR of the constructs by applying PLS-SEM and CB-SEM, it can be observed in Table 32 that the PLS-SEM obtained better results than the CB-SEM in all groups. The **quality** construct for having a single indicator presents values of CR, factor loading, and AVE equal to 1 in all cases. The comparative results of the general structural model for all groups are shown in Table 34, Table 35, and Table 36.

The **trust** construct exerts a greater influence on the **quality** construct and presents a higher R^2 in the CB-SEM than in the PLS-SEM for all the groups. The value constructs a greater influence on the **quality** construct in PLS-SEM than in CB-SEM; however, CB-SEM presents a higher R^2 than PLS-SEM for all groups. In PLS-SEM, there is almost always the greater influence of the **trust**,

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Tabela 33. Comparison of measurement models of groups using the factor loadings.

	Construct	**Mean FL**[1]	**Mean Max (SFL)**[2]
Group 1 PLS-SEM	Trust	0.907	0.695
	Quality	1.000	0.822
	Value	0.890	0.367
	Satisfaction	0.768	0.632
	Loyalty	0.879	0.399
Group 2 PLS-SEM	Trust	0.905	0.683
	Quality	1.000	0.804
	Value	0.911	0.387
	Satisfaction	0.769	0.620
	Loyalty	0.885	0.400
Group 3 PLS-SEM	Trust	0.896	0.675
	Quality	1.000	0.807
	Value	0.884	0.345
	Satisfaction	0.751	0.607
	Loyalty	0.869	0.375
Group 1 CB-SEM	Trust	0.873	0.70
	Quality	1.000	0.835
	Value	0.850	0.344
	Satisfaction	0.797	0.638
	Loyalty	0.839	0.403
Group 2 CB-SEM	Trust	0.871	0.687
	Quality	1.000	0.822
	Value	0.879	0.361
	Satisfaction	0.755	0.632
	Loyalty	0.846	0.401
Group 3 CB-SEM	Trust	0.858	0.683
	Quality	1.000	0.827
	Value	0.842	0.318
	Satisfaction	0.735	0.619
	Loyalty	0.825	0.374

[1]Factorial Load, [2]Maximum Cross-factor Loading.

Tabela 34. Comparison of the **Group 1** structural model.

Endogenous	**Exogenous**	β		R^2	
		PLS-SEM	**CB-SEM**	**PLS-SEM**	**CB-SEM**
Quality	Trust	0.675	0.796	45.5%	49.1%
Value	Quality	-0.236	-0.16	5.6%	5.9%
Satisfaction	Trust	0.388	0.379	75.8%	79.0%
	Quality	0.559	0.41		
	Value	-0.004	0.004		
Loyalty	Trust	0.345	0.313	21.5%	17.8%
	Satisfaction	0.143	0.06		

Tabela 35. Comparison of the **Group 2 structural model**.

Endogenous	**Exogenous**	β		R^2	
		PLS-SEM	**CB-SEM**	**PLS-SEM**	**CB-SEM**
Quality	Trust	0.665	0.817	44.3%	47.6%
Value	Quality	-0.22	-0.176	4.8%	5.1%
Satisfaction	Trust	0.391	0.395	73.3%	76.3%
	Quality	0.542	0.392		
	Value	-0.011	-0.001		
Loyalty	Trust	0.341	0.3	21.2%	17.6%
	Satisfaction	0.145	0.07		

quality, and **value** constructs on the **satisfaction** construct than in CB-SEM. Still, in CB-SEM, the quality of the model fit is better because of the higher R^2 when compared to PLS-SEM in all groups. Finally, the **trust** construct and **satisfaction** construct exerted a greater influence on the **loyalty** construct and presented a higher R^2 in PLS-SEM than in CB-SEM for all groups.

4.8. Discussion

The proposed analysis model comprises five evaluation items: quality, value, satisfaction, trust, and loyalty, whose scores are calculated based on the household survey carried out by ANEEL. In this proposed model, cause and effect are measured to ensure the performance comparison history of

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Tabela 36. Comparison of the **Group 3 structural model**.

Endogenous	Exogenous	β		R^2	
		PLS-SEM	CB-SEM	PLS-SEM	CB-SEM
Quality	Trust	0.665	0.812	44.2%	48.1%
Value	Quality	-0.236	-0.162	5.6%	6.0%
Satisfaction	Trust	0.387	0.382	73.6%	77.3%
	Quality	0.549	0.385		
	Value	-0.004	0.004		
Loyalty	Trust	0.33	0.28	20.0%	15.9%
	Satisfaction	0.141	0.049		

distributors over the years. The item satisfaction results from the model considering the concessionaires and licensees together. In the presentation of the results (path diagram), the coefficients β that link the evaluated constructs represent the marginal impact of the antecedents, i. e., where the arrows leave, to the focal points, which is where the arrows arrive. For example, for $\beta = 0.7$ between quality and satisfaction is indicative of a trend of 0.7 growth in satisfaction for each point of increase in quality. In this way, so that managers can monitor the quality of the service provided, it is enough to compare the previous β with the current β. The R^2 index can also be used to monitor the quality of services provided. This index assesses how much the change in the focal variable is explained by its antecedents, and the closer to 1, the better the ability to explain the variation in relationships. Thus, managers must monitor the values of R^2 annually to compare how the model variables behave.

Several studies measure consumer satisfaction in different segments of essential services, but studies on electricity concessionaires are incipient. To ensure survival and profitability in a competitive scenario, electricity concessionaires must develop tools capable of measuring and supporting the management of the quality of services provided, perceived quality, and consumers' behavioral intentions. Therefore, this study sought to consider the potential arising from comparing structural equation modeling by partial least squares (PLS-SEM) and based on covariance (CB-SEM). To verify the quality of the PLS-SEM and CB-SEM structural equation modeling adjustments, indices and metrics were used, such as average variance extracted AVE, composite reliability CR, coefficient of determination R^2, and quality of fit GoF. In the CB-SEM approach, specific parameters are also used to assess the quality of the model, such as comparative fit index (CFI), Tucker-Lewis index (TLI), and root mean square error of approximation (RMSEA), in addition to the p-value to verify if the RMSEA is statistically within the desired.

For PLS-SEM, the trust construct explains 45.2% of the variability in the **quality** construct, and if the residential consumers of electric energy perceive that the electric energy concessionaire or licensee is trustworthy and provides true information; consequently the quality perceived by the provision of services tends to be higher. In addition, in PLS-SEM, the **quality** construct explains 5.7% of the variability of the **value** construct, so if the services provided have quality concerning customer expectations, then the amount paid will tend to be considered fair. In the **trust** construct on the **satisfaction** construct, it is measured that if the residential electric energy consumers perceive that the electric energy concessionaire or licensee is trustworthy and provides true information; he will be more satisfied. The influence measured between the **quality** construct on the **satisfaction** construct defines that if the services provided have a quality assessment in relation to customer expectations, there will be a tendency for the customer to be satisfied. There is also the influence of the **value** construct on the **satisfaction** construct, defining that the higher the amount paid in energy bills, the lower the customer satisfaction. The **trust**, **quality**, and **value** constructs can explain 74.4% of the variability of the **satisfaction** construct, and the**trust** and **satisfaction** constructs explained 21.8% of the variability of the **loyalty** construct.

For the CB-SEM, regarding **quality**, there was an influence of the **trust** construct, and the greater the **trust**, the greater the **quality**, since the **trust** construct was able to explain 48.8% of the **quality** variability. The **value** construct is influenced by the inverse of the **quality** construct, and the higher the quality perceived by the customer, the more he will feel that the amount paid is high. **Quality** explained 6.0% of the variability in the **value**. Regarding **satisfaction**, there was an influence on the **trust** construct, with the greater the **trust**, the greater the **satisfaction**. There was also an influence of **quality** on **satisfaction**, so that the higher the **quality**, the greater the **satisfaction**. Finally, there was no significant difference of the **value** on **satisfaction**. The **trust**, **quality**, and **value** constructs together explained 77.7% of the variability in **satisfaction**, **trust**, and **satisfaction**, explaining 18.2% of the variability in **loyalty**.

For the choice of which model to apply, from the perspective of the coefficients of determination R^2, the CB-SEM would have better quality in the model adjustments because R^2 of its relations is higher when compared to R^2 of the PLS-SEM relations. This indicates that the independent constructs of CB-SEM better explain the dependent constructs. However, if the average variance extracted AVE is used, for example, PLS-SEM can be chosen as the model that produces better measurement quality. The results of PLS-SEM and CB-SEM in this study are closely related, with small differences in the quality of the measurement model. Both approaches return, analyzing only the adjustment inputs and the same results. As a result, it is not possible to say that one method is better than another. However, to correctly apply PLS-SEM and CB-SEM, users must understand the purposes for which each approach was developed and applied to generate satisfactory results.

Consumers expect electricity distributors to improve and become increasingly suited to economic and financial reality, delivering quality in the electricity supply. The IASC honors, for the most part, the best-rated distributors only based on the opinion of urban residential consumers. The analysis performed by the IASC needs to be improved to obtain the perceptions of all categories of consumers. The numbers measured in this work are essential to map and monitor the concessionaires. Still, the perception expressed by consumers is critical to the evaluation of electricity distribution services, contributing to the improvement of these services.

In this research, the ANEEL Consumer Satisfaction Index (IASC) was used to assess residential consumer satisfaction with services provided by electricity distributors, model derived from the American Customer Satisfaction Index (ACSI) satisfaction model. The measures used in structural equation modeling (SEM) were developed from a solid theoretical framework by analyzing the psychometric characteristics of the measurements. The PLS-SEM and CB-SEM methodologies tend to be complementary because the advantages of the non-parametric and variance-based approach can be the disadvantages of the parametric and covariance-based system and vice versa. New research is being carried out to develop a global measure of adequacy for PLS-SEM. This model evaluation criterion is a fundamental requirement for testing and comparing alternative theories with their associated models. Furthermore, future research may contemplate different approaches for response-based clusterings, such as FIMIX-PLS, PLS genetic algorithm segmentation, and PLS response-based unit segmentation (REBUS-PLS).

In the analysis carried out for the PLS-SEM in Table 12 and Figure 4 it is observed that β = -0.238 of the **quality** construct over the **value** construct. Similarly, using CB-SEM, Table 13 and Figure 5 show that the value construct was influenced by the **quality** construct, raising β = -0.175. This is due to the characteristics of the electricity sector in Brazil. This service does not have another energy supply option and does not yet have sufficient capacity to bargain with its suppliers. In most cases, the improvement in service quality does not correspond to a fuller perception of the value perceived by the user since there is a monopoly. Factors that directly affect rates, such as increases, reductions, discounts, and installments, should have a greater impact on perceived value than on changes in service quality. This fact also explains the common characteristics associated with the continued consumption of services. In these circumstances, the expectations generated have a normative character; that is, the service standards are the references for users to evaluate them. At the same time, they have a low capacity to negotiate with energy suppliers, which means that they cannot change their electricity costs regardless of the quality provided. Therefore, the relative weights between **quality** and **value** result in low values.

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There is a long-term tendency for distribution concessionaires to increase the number of customers, thus increasing their market and being forced to improve their management practices. However, there is an index defined by ANEEL that is used at the time of the tariff review, the X-Factor. X-Factor works as a reducer of the readjustment rates of the tariffs charged most of the time. Its function is to pass on to customers the estimated productivity gains of the concessionaire resulting from market growth. One of the components of X-Factor assesses the quality of technical and commercial services provided by each distributor to its customers. Therefore, if a concessionaire provides inadequate service, the penalty will reduce the readjustment of the tariffs charged. In this way, this work serves as an overview for distributors to pay attention to service improvement opportunities, increase their earnings, and provide quality service.

5. Conclusions

This study presented as its general objective the application of structural equation modeling by partial least squares (PLS-SEM) and structural equation modeling based on covariance (CB-SEM) to assess the satisfaction of residential electricity consumers about utilities and licensees that provide the services. For this, the specific objectives included conducting an exploratory and descriptive analysis of the data from the Consumer Satisfaction Index. The study's objectives were achieved, as the comparative analyses of convergent validity, discriminant validity, and reliability of the constructs for the measurement models demonstrated that PLS-SEM and CB-SEM are complementary and not concurrent so that a method cannot be considered superior to the other.

The weights relative to the **quality** and **value** constructs resulted in low β values. This is because users have little bargaining power with their energy suppliers. Regardless of the product quality they deliver, residential consumers cannot change their electricity costs. On the other hand, the application of PLS-SEM and CB-SEM results in higher β values between the **trust** and **quality** constructs, which highlights the high impact of users' trust in the quality of the service. Therefore, investments in improving distribution systems, service systems, access to the concessionaire/licensee, and information to users lead to greater trust. Therefore, companies must seek to improve the quality of their services so that consumers remain secure about the offer of these activities.

This study used data from a consumer satisfaction survey questionnaire in all the Brazilian regions. In this way, this research brings the general panorama about the services rendered by the analyzed concessionaires/licensees, as the result of the structural equation models, the average of the countless companies evaluated. Thus, the results of this work can be used to monitor and analyze consumer satisfaction, observe the evolution of the quality of services provided, and assist in developing tools to support decision-making at concessionaires. Residential electricity users can also use this study to understand better the aspects that need improvement on these service providers, based on which demand from the competent supervisory body fulfills the proper electricity distribution procedures.

Therefore, we concluded that the significant portion of the variability incident on customer satisfaction could be explained by the trust, quality, and value constructs, with 74.4% when applying PLS-SEM and 77.7% when applying CB-SEM. This indicates that user satisfaction can be achieved if the electricity concessionaires/licensees demonstrate concern for the interests of the customer/user, including providing correct and accurate information when requested. Another factor that can lead to user satisfaction is the perceived quality, represented by i) product quality that is related to constant voltage compliance and non-disturbed waveform, ii) quality of service that is related to the continuity of its provision, and iii) quality of customer service. Currently, there is a natural monopoly on the electricity distribution service. Although consumers are dissatisfied with the amount paid for their bills, they cannot turn to another company and end up not exercising their right to choose.

This study proposes the model of evaluating consumer satisfaction for the electricity sector. There is the insertion of the structure that meets the services provided by electricity distributors. The results obtained show that the model has validity and internal consistency because the results obtained by PLS-SEM and CB-SEM are similar. The proposal presents a flexible model to measure the satisfaction of residential customers in the context of different concessionaires/licensees. The association model can be established for each distributor, indicating the diagnosis of problems and their possible solutions. Similarly, the model allows concessionaires/licensees to maintain the database on the evolution of these indicators measured using the proposed methodology and evaluate the development of consumer satisfaction in the face of suggestions for improvement strategies.

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