ASSESSMENT OF THE ENERGY COOPERATIVE SERVICE: THE CASE OF ELECTRICITY DISTRIBUTION COOPERATIVES IN BRAZIL

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ABSTRACT

The creation of energy cooperatives has been frequently justified by the need to supply energy to remote regions which were not economically attractive to large companies. These cooperatives emerge in different energy sectors, including generation and distribution and more recently with a focuses on renewable energy. Brazil followed also this cooperative approach for the electricity distribution sector which could be easily justified by the dimension of the country and population dispersion. The interest of the cooperative models has been challenged recently based on the argued lower performance comparatively to larger companies. This paper proposes a framework for the assessment of the cooperative customer's satisfaction which was applied to the case of five electricity distribution cooperatives located in Northeast of Brazil. The case demonstrated the suitability of the proposed framework to deal with the required specificities of the target population and showed the higher performance of the cooperative for several criteria and in particular to aspects related to consumers' relationship.

INTRODUCTION

The energy production and distribution system are crucial to guarantee the maintenance and development of a country's economic and environmental wellbeing. The recent technological advances in the electric power grid, allowed for the emergence of different models for the generation and distribution activities on the field of electricity system which is one important part of the entire country's energy system. This new technical and market paradigms gave rise also to changes on the norms of the electric sector, in order to promote the integration of diverse business typologies and stakeholders into the complex chain which makes up the energy system of a country (van der Horst, 2008). These changes turn the electrical system more complex both from a managerial and infrastructural point of view. The need to promote actions to continuously improve control and quality standards emerges as a fundamental challenge to ensure that these standards meet the expectations of all stakeholders involved in the energy marketing system.

Huybrechts & Mertens (2014) studied the recent emergence of the cooperative model in the field of renewable energies and concluded that in most countries the renewable energy sector has been mainly dominated by corporate actors skilled in building large-scale projects. However, the emergence of social initiatives under a range of structures and designations can make an important contribution to tackle challenges related to the hegemony of large private corporations, lands availability and the required flexibility for the electricity sector. For instance, Van der Horst (2008), analyzed the UK case describing some benefits generated by government that extended its support to integrate social enterprises in the development of the renewable energy sector.

Huybrechts & Mertens (2014) claimed that citizen groups frequently prefer adopting the cooperative model or a related form according to the local legislation and context to entry in energy market. Traditional cooperatives, such as agricultural, banking or health services are already largely explored in the specific academic literature. By contrast, due to the novelty of the insertion of the cooperative model in the field of the generation from renewable energy and distribution there is little literature on methodologies and procedures to evaluate the quality and consumer satisfaction of the services provided by them. Some existing assessment frameworks seems inappropriate to evaluate scenarios composed by low-income and low-educated consumers which are frequent in remote and agricultural regions.

Considering the context previously presented, this work intends to contribute to the debate on both energy cooperatives and energy quality assessment. For this, the paper will address focus on three main objectives: (1) design of a framework for the assessment of the cooperative customer's satisfaction with energy service provided; (2) test of the framework on

five electricity distribution cooperatives located in Northeast of Brazil; (3) compare the cooperatives performance with that of the local energy distribution company.

RELATED WORK

Cooperative Models in the Energy Sector

The cooperative model appears as an alternative to existing private enterprise model. Accordingly to the literature, the first cooperative experience occurred in the UK in 1844, with the founding of the Rochdale Equitable Pioneers Society for some it is considered the birth of modern cooperatives (Hentschel, Ketter, & Collins, 2018). The International Cooperative Alliance defines cooperative as "an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise" (International Cooperative Alliance, 2019).

In the past, the use of the cooperative model in the energy sector occurred as a way of providing energy to remote regions that were not economically attractive to large sector providers. Hentschel et al. (2018) stated that in the end of the 19th century in Germany, local communities created cooperatives to address deficiencies of the infrastructure grid related to the production and distribution of energy. In the Brazilian framework, the cooperatives have been in action on the electrical sector since 1930s on the basis of state incentives, community effort of rural residents who wanted to enjoy the benefits of electricity or even as an incentive for large concessionaires who preferred cooperatives to take over the distribution of remote and unprofitable areas (Munaretto, 2015). The first Brazilian energy cooperative came into being in 1941, in the south of the country, with the objective of generating and distributing electricity to a small locality on which a colonizing company in the region was based and then later supplied energy to the local agricultural industry. Thus, the Brazilian cooperatives followed a paradigm similar to the German case described above: aiming for respond to the electrification needs of residents on small urban centers. Later on, the cooperatives expanded their operation and started to encompass also the rural areas. Later, in the 1970s, the Federal Government, with resources from the Inter-American Development Bank (IDB), started to finance cooperatives interested in expanding their distribution network in remote rural areas not served by large electrification companies (Pasin, 2013).

Cooperatives can operate in several economic sectors or branches. The Organization of Brazilian Cooperatives classifies cooperatives in 13 branches and for the case of electricity distribution sector, these are coined as the infrastructure cooperatives which supply fundamental services to their associates. Since its inception, this segment has expanded until 1996. The creation of the national regulatory agency for energy (National Electricity Energy Agency, in Portuguese, ANEEL - Agência Nacional de Energia Elétrica) in 1990 gave rise to new regulations in the sector. The activities of energy cooperatives was reframed under Resolution 333/1999 (ANEEL, 1999), which established additional rules for a new granting of public service permits. That process led to a strong reduction in the number of active electrification cooperatives. In a survey conducted by Cardoso and Camilo (2018), from 260 existing ones in 1980, only 69 remained active in 2016, corresponding to 26.5% of the total. The main argument used by the regulatory agency for the new regulation was the alleged inability of smaller institutions to provide a quality service to the end users of the service. ANEEL also established a set of indicators to assess the quality of the electrical distribution and commercialization process.

In 2012 with the publication of Resolution 482/2012, the ANEEL allowed consumers to generate their own electricity from renewable sources. This energy could be consumed or injected into the grid, in this case, generating energy credits that can be consumed in up to five years. Subsequently this Resolution was updated by the Resolution 687/2015 which opened a new possibility for cooperatives business models based on shared generation among cooperative members installed in several areas of the electricity network. From then on, these cooperatives were able to distribute their surplus in the network for remote self-consumption by other cooperatives connected to the network (ANEEL, 2012, 2016). This change in legislation was received by cooperative associations as a new opportunity to expand electrification cooperatives in the sector (Böckler & Pereira, 2018; Paris-Junior, Takigawa, Aranha-Neto, & Fernandes, 2018).

Service's Quality and satisfaction

The improvement of service's quality has been a goal pursued by all companies independent on field of activity, since their improvement can increase its productivity and the competitiveness. According to Anderson, Fornell and Mazvancheryl (2004) a service has good quality if it satisfies the final users. The development of customer satisfaction indices (CSI) for a myriad of purposes has then cached attention from scholars and practitioners. Chiandotto, Bini and Bertaccini (2007) stated that these frameworks can result from two patterns of analysis: transaction-specific satisfaction and cumulative satisfaction. The mentioned authors also realize that initially the phenomenon was considered as a result of single episodes of consumption, later the overall psychological satisfaction after the use of a service, that is, the satisfaction is a result of the cumulative perception of all the interactions with the service.

The first framework designed to assess customer satisfaction was develop in Sweden in 1989, called Swedish Customer Satisfaction Barometer (SCSB), followed by Germany in 1992, USA which proposed the American Customer Satisfaction Index (ACSI) in 1994, then by Norway which in 1996 created the Norwegian Customer Satisfaction Barometer (NCSB)

and, finally the European Customer Satisfaction Index (ECSI) was created in 1998 (Chiandotto et al., 2007; Oliveira, Gonçalves Filho, Gonçalves, & Souki, 2008). The American Customer Satisfaction Index is used by the USA Government to control and set goals related to the country's competitiveness in its various sectors.
Brazil does not have a broad national framework to evaluate the satisfaction in various sectors. It is usual in the literature to adapt the American or European satisfaction indexes to evaluate specific sectors, such as the work of Moura and Gonçalves (2005) who adapted the American model to evaluate satisfaction with the mobile service, or the work of Lopes, Pereira and Vieira (2009), who used the American and European tools to evaluate customer satisfaction towards banks, vehicle dealers, credit cooperatives, post offices, hospitals and mobile shops.

The case study: customer satisfaction from five Brazilian cooperatives

On the specific case of the Brazilian electricity sector, the National Electric Energy Agency (ANEEL) has created a Consumer Satisfaction Index based on the models presented above (ACSI and ECSI). The ANEEL satisfaction assessment framework has been adopted since 2000 and it is composed by the five following dimensions: (a) Perceived quality; (b) Perceived value; (c) Global Satisfaction; (d) Loyalty to the Electric Power supplier; and e) Supplier Trust (Marchetti & Prado, 2004). Another existing index is from the Brazilian Association of Electric Power Distributors (Abradee – Associação Brasileira de Distribuidores de Energia Elétrica, in Portuguese) which since 1999 conducts a customer satisfaction survey of its more than 50 member companies to reward those who have the best performance in the index. This index has 26 items grouped into five dimensions: electricity bill, image, supply, service and information (Oliveira, 2016).
In 2009, in the context of ANEEL Resolution 333/1999, five cooperatives were being expropriated in favor of the large company that served the region in which the cooperatives were located. The argument used by ANEEL to justify the process was that cooperatives, because of their small size, could not offer a service that would satisfy their end users, bringing vulnerability to the system as a whole. In order to legally confront this claim, the cooperatives decided to measure the satisfaction index of its users. Meanwhile, the method adopted by ANEEL Customer Satisfaction Index (IASC, in Portuguese) for satisfaction measurement was argued to be inappropriate to evaluate the comparative satisfaction of end users, for two main reasons: firstly, due to the methodology of data collection which resulted in a small and pulverized sample, making it unachievable to analyze the cooperatives performance individually. Secondly, the variety and number of items included in ANEEL's official model was difficult to be fully understood and the difference between some of the items was not clear to the respondents. The specificity of some items made it unintelligible to the sample of respondents marked by low educational background. The alternative assumed to face the ANEEL legal claim was to develop a new framework, that would allow the comparison of the results. For strategic and legal reasons, the procedures adopted for the construction of the new tool, analysis, as well as its results were kept confidential until 2018.

METHOD

A framework well suited to assess cooperative customer's satisfaction in what concerns the energy service provided was designed. This framework was then used on the performance evaluation of five cooperatives in the rural electrification sector located in the Northeast region in Brazil. The methodological approach is deductive and mainly quantitative. Table 1 presents the methodology followed to design and apply the assessment framework and to draw conclusions.

Table 1 Methodological process

Step	Procedure	Description
1º	**Extend literature review**	Understand the market context in which the electrification cooperatives are inserted; Identify the main descriptors of the satisfaction of electricity distribution service users to generate the items the model.
2º	**Survey pre-validation and questionnaire debugging**	Elaborate a questionnaire and apply it to a reduced sample in the form of a pilot test. Evaluate the results and promote the necessary changes for application in a larger representative sample.
3º	**Survey to data collection**	Application of the questionnaire to a representative sample.
4º	**Systematization and data analyze**	Perform a set of statistical techniques (descriptive statistics, scale reliability analysis with the Cronbach Alpha statistic and principal component analysis) to build and validate the model.
5º	**Results comparison**	Comparison of the performance of cooperatives in relation to the company responsible for the distribution in the area of cooperatives.

The survey resulting from step 1 and used in step 2 was composed by: (a) six demographic variables (customer's home code, gender, age, family income estimated, number of residents, educational background); and, (b) thirty items distributed as follow: 17 related to Perceived Quality component; 3 related to Value; 3 related to Global Satisfaction; 4 related to the Supplier Trust component and 3 related to Loyalty, the same structure adopted by ANEEL Customer Satisfaction Index (IASC, in Portuguese) and, in addition, (c) six more items taken from satisfaction index created by Brazilian Association of Electricity Distributors (ABRADEE, in Portuguese) (Oliveira, 2016). Thus, the preliminary survey was composed by a set of 42 variables.
The specific goals established on step two were to (a) assess respondent's reaction and understanding of the items and variable allocated on the questionnaire; (b) obtain feedback on the length, format and clarity of the survey tool. In the

pilot test, considering the low educational background of the population, it was decided to apply structured and assisted survey. A research team member, trained not to influence the answers, supported the data collection by explaining the Likert-scale response procedure and the reason for the investigation, reading the survey questions and items to the respondent and finally writing down the answers given by them. A small number of individuals from one of the cooperatives was chosen for the pilot test. As a result of this pilot test, 10 items were withdrawn because they were not clear to the respondents, remaining a set of 32 items in the final questionnaire.
After the pilot test, it was decided to maintain the same procedure of collecting data through a face-to-face survey for the whole sample (step 3) due to the high number of illiterate respondents. After data collection a statistical analysis of the results was conducted in step 4. In this phase, as will be demonstrated in the topic of results, other items were discarded due to their lack of statistical adherence to the proposed new model.
The comparison between the two business models (step 5) relied on information from this survey and from the Consumer Satisfaction Report – EPB (ANEEL, 2009) for the main distribution company operating in the region.

RESULTS

Sample characterization

The data collection resulted from the survey for which responses from 613 individuals were obtained, as presented in Table 2. The population included 26,219 rural consumers of the electric distribution services of five cooperatives operating in the Northeast Brazilian rural area. The sample size, considering p equals to 0.05, has an error estimated in ± 3.91.

Table 2 - Samples profile

Cooperative	Transmission line (n)	Consumer population	Sample	(%)	Consumer Gender (M-F)	Average Monthly Family Income	Average Age
Cooper 1	7	7329	137	0,52	82-55	€ 244.87	46.6
Cooper 2	6	6555	160	0,61	56-104	€ 243.82	47.89
Cooper 3	4	3631	135	0,51	49-86	€ 239.56	42.07
Cooper 4	10	7518	134	0,51	49-85	€ 227.69	45.01
Cooper 5	2	1186	47	0,17	20-27	€ 230.25	46.87
TOTAL	29	26219	613	2,33	255-357		

As presumed the sample is characterized by low schooling and low incoming. More than half (59.6%) have only basic education, 26.8% of them are illiterate. Only 2.4% have higher education and 11,1% have high school. The majority of the respondents are females (58.2%). The mean age of the respondents is 45.61 years with 17.17 years of standard deviation and an amplitude of 77 years, with 15 years the youngest respondent. The average monthly income is € 232.22 (SD €150.59) as described in Table 2.

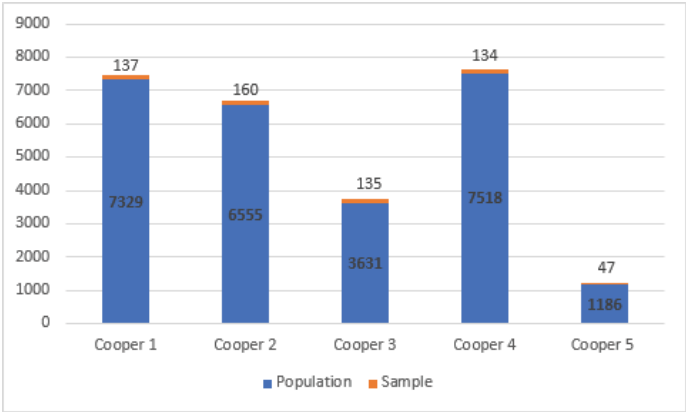

Figure 1 - Population and sample distribution

The study included a small cooperative (Cooper 5), which had only two transmission lines and supplied a few more than 1,000 consumers, one medium-size (Cooper 3) with four transmission lines and more than 3,500 consumers and three larger ones with six (Cooper 2), seven (Cooper 1) and ten (Cooper 4) transmission lines and all of them supplying more than 6,500 consumers, as presented in Figure 1.

Scale's Reliability

The Cronbach's alpha coefficient calculates the average of all possible measures of split halves, resulting from different ways of dividing the variables of the scale. The coefficient ranges from 0 to 1, values close to one indicate adequate internal consistency (Hair Jr., Celsi, Ortinau, & Bush, 2014). According to Hair Jr. et al. (2005), the idea underlying the internal consistency analysis is that the individual items of the scales must measure the same component therefore must be highly intercorrelated. To Corrar, Paulo, & Dias-Filho (2007) values greater than 0.6 are accepted, although values closer to one indicate a better reliability of the data. The internal consistency of each subscale (Supplier Trust: 0.828, Perceived Quality: 0.736; and Customer's Relationship: 0.642) is presented Table 3.

Cortina (1993) argues that several elements influence the statistical Cronbach's alpha, including the number of items on the scale. The third component, Customer's Relationship, presented in Table 3**Error! Reference source not found.**, having only three items is the one with the lowest coefficient. The decision to keep it, is based not only on the still acceptable value (higher than 0.6) but also on what was considered the conceptual importance of the items for the service provided (Corrar et al., 2007).

Principal Component Analysis and Scale Reduction

A principal component analysis was conducted on the 27 items of the orthogonal rotating instrument (varimax) in a sample of 613 participants. The initial solution resulted in five components, however the model presented adjustment issues after a sequence of iterations, each involving eliminations of items with low loadings on all factors or high cross-loading on two or more factors, followed by factor analysis of the remaining items. This iterations process results in the final solution of a set of 17 items grouped into three components which represent the main facets of consumer satisfaction related to electricity provided service. The Kaiser-Meyer-Olkin measure verified the sample adequacy for the analysis (KMO = 0.906) and all KMO values for the individual items were equal or greater than 0.88. The KMO statistic is a measure of sampling adequacy of overall variables. The Bartlett sphericity's was used to test whether the correlation matrix is an identity matrix, which would indicate that the factor model is inappropriate. The result [[$\chi^2_{(105)} = 2982.553$, $p < 0.001$] indicated that the correlations between the items are well suited to proceed with the principal component analysis.

The final analysis showed that three components obeyed the Kaiser criterion of the eigenvalue (greater than 1), explaining 53.075% of the variance. The scree plot also showed that those three components are positioned before inflexion. Considering the sample size and the convergence between the scree plot and the Kaiser criterion, this was the number of components maintained in the final analysis. The rotated eigenvalues for the components and the percentage of explained variance for the three components were respectively, for the first 3.180 (21.199%); for the second 2.773 (18.496%); for the third 2.008 (13.390%).

The reliability results of the subscales and the statistical tests (KMO, Barllet, MSA) confirm the model's factorability, attesting that Supplier Trust, Perceived Quality and Consumer's Relationship are determinant dimensions of consumer satisfaction of electricity services.

Table 3 summarizes the results of the principal component analysis. In the first column the items segmented by their respective components are presented, the second column shows the factorial scores (FS) that correspond to the linear combinations between each item and its component. From the third to the seventh columns the average values obtained by each analyzed cooperative (Coop. 1 to Coop 5) are presented, for each of the items listed in the first column. The eighth and ninth columns shows full sample (n=613) means and standard deviations, respectively.

In the first line of each component the following values are described: the average value of the component, the eigenvalue, that corresponds to the sum of the column of squared factor loads for each component, and the explained variance which refers to the amount of variation in a component that is explained by a given component. This statistic is followed by the MSA range that shows the smallest and largest value of the Measure of Sampling Adequacy of each item. According to Field (2009) and Luque-Martínez (2012) values above 0.50 were accepted. The last statistic presented in this line is the Cronbach's Alpha. Finally, in the last line of each component the average component values for each cooperative are presented.

Among the three components, the Consumer's Relationship model was the one that obtained the best performance of the respondents, with an average of 8.21, followed by the Supplier Trust component, with an average of 6.81. The Perceived Quality had the lowest score of 6.15, however the value is higher than the midpoint of the scale indicating moderate satisfaction Table 3.

Table 3 - Synthesis of Principal Components and performance analysis and reliability results

Rotary component matrix[a]								
		Cooperatives					Cooperative Global sample	
	FS	Coop 1	Coop 2	Coop 3	Coop 4	Coop 5	**Ave-rage**	**Std Dev.**
Component 1 – Supplier Trust (comp**. m**ean: 6.81; eigenvalue: **3.180**; explained variance: **21.199** %; MSA ranging between 0.**883** and 0.9**38; ** Cronbach's alpha**: .828**)								
The cooperative acts against the occurrence of energy thefts and frauds – CONF1	**.668**	8.55	6.12	8.42	7.8	5.7	**7.51**	**3.07**
The cooperative cares about the interests of customers – CONF2	**.653**	6.42	4.34	6.09	5.83	4.23	**5.51**	**3.17**
The cooperative is flexible and willing to negotiate with its clients – CONF3.	**.652**	8.72	5.98	7.86	8.18	5.85	**7.48**	**2.91**
The cooperative is responsible for providing the services – CONF4	**.650**	8.3	6.22	7.74	7.39	5.1	**7.19**	**2.76**
The cooperative is always investing to provide more quality energy – CONF5	**.620**	7.86	4.68	7.45	6.19	4.23	**5.11**	**3.88**
Cooperative is attentive and respects the rights of customers – CONF6	**.612**	7.85	5.85	7.78	6.78	5.6	**6.91**	**2.75**
The cooperative is concerned with the preservation of the environment – CONF7	**.565**	7.74	5.54	7.85	6.79	5.36	**6.8**	**2.85**
Average		**7.95**	**5,54**	**7.56**	**7.03**	**5.12**		
Component 2 – Perceived Quality (comp**. m**ean: 6.15; eigenvalue: **2.773**; explained variance: **18.486**%; MSA ranging between 0.**893** and 0.9**29; ** Cronbach's alpha**: 0.736**)								
There is a rapid system restore when power is cut off – PQ1	**.752**	7.31	5.34	7.44	5.1	5.01	**6.17**	**2.94**
There is uninterrupted power supply – PQ2	**.740**	7.16	4.84	7.45	5.87	5.43	**6.2**	**2.82**
In case of maintenance, consumers are informed in advance about the interruption of the power supply – PQ3	**.637**	6.83	4.19	6.34	2.64	3.51	**4.86**	**3.64**
Power supply occurs without voltage variation – PQ4	**.623**	7.26	4.84	7.09	6.07	5.04	**6.16**	**2.92**
Consumers find it easy to contact the cooperative – PQ5	**.475**	8.51	6.79	7.73	7.19	5.54	**7.37**	**3.03**
Average		**7.41**	**5.20**	**7.21**	**5.38**	**4.90**		
Component 3 – Consumer's Relationship (comp**. m**ean: 8.21; eigenvalue: **2.008**; explained variance: **13.390** %; MSA ranging between 0.988 and 0.947**; ** Cronbach's alpha**: 0.642**)								
The cooperative facilitates the procedures for payment of bills – CR1	**.762**	7.83	7.94	8.19	7.09	8.04	**2.63**	**7.83**
There is cordiality in the service provided by the employees of the cooperative – CR2	**.695**	8.13	8.94	8.89	7.56	8.61	**2.29**	**8.13**
The cooperative is concerned with providing equal care – CR3	**.654**	7.1	7.94	8.77	7.02	7.96	**2.65**	**7.1**
Average		**8.69**	**7.68**	**8.27**	**8.61**	**7.22**		

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser normalization[a]; a. The. Rotation converged in 5 iterations.

The lowest performing cooperative in all components was Coop5, the smallest cooperative analyzed, both in terms of number of transmission lines (2) and number of clients served 1,186. This low performance may indicate that the size of the cooperative affects the satisfaction level of the users, however a larger population would be necessary to test this hypothesis.

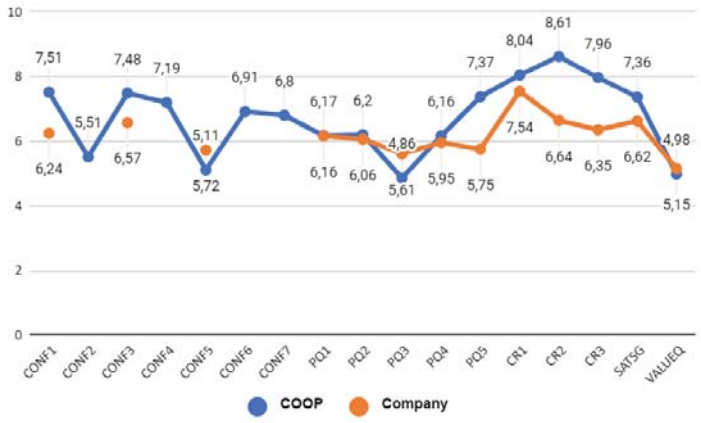

Figure 2 - Comparative performance of the energy distribution service

The benchmarking of the performance result obtained by the cooperatives was carried out in comparison to the result of the large company responsible for the distribution of electric energy in the region. The data shown in **Error! Reference source not found.** demonstrate that from 17 items considered by the new model created from cooperatives, 13 were common to both models and therefore could be compared. Of these, 13 common items, the cooperatives obtained superior performance in 10 items. This result demonstrates that in several factors related, for example, to consumer's relationship and contact the proximity of the cooperatives to the consumers is a remarkable positive aspect. On the other hand, large companies still have a higher ability raise capital and proceed with investment. In summary, the results challenge the argument that cooperatives should be expropriated because they do not have the structure to offer a quality service that satisfies their final consumers.

CONCLUSIONS AND FURTHER RESEARCH

To meet the stipulated objectives, a new assessment framework was developed and applied to evaluate the performance of five energy distribution cooperatives based on the consumers' assessment of a set of indicators. The framework, although departing from an initial one proposed by ANEEL was adapted to the target community characterized by mostly low-income and low-educated residents in remote rural areas.

Comparing the performance results with the large energy distribution company, it was possible to verify that the cooperatives outreach the large company is most the analyzed aspects. This fact challenges the argument that cooperatives, because of their structure, could not provide a quality service that would satisfy their clients. Cooperatives, even with size constraints and little state incentive, achieved high levels of satisfaction.

The proposed methodology showed that the reduction of the number of items in the scale, supported by the appropriate methods of statistical analysis, facilitates the assessment of the performance of companies in the energy sector. It is also important to highlight that the implementation based on a face to face survey allowed for the collection of information from all segments of clients, including those with low educational background (illiterate).

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