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EVALUATION OF THE EFFECTIVENESS AND THE EFFICIENCY OF THE LUZ PARA TODOS PROGRAM

AVALIAÇÃO DA EFICÁCIA E DA EFICIÊNCIA DO PROGRAMA LUZ PARA TODOS

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Abstract

The government of Brazil implemented, in 2003, the "Luz para Todos" (LPT) program. Since it is a public policy of significant socioeconomic impact and substantial government investment, it is necessary to evaluate its results. Thus, this article aimed to evaluate LPT in terms of effectiveness and efficiency. For this purpose, an indicator of attendance of its goals was constructed and a Data Envelopment Analysis model was applied. The results indicate that most of the Brazilian states had already surpassed the electrification goal until 2014. Among the exceptions, there is a concentration of states in the North region. On the other hand, the most efficient states were concentrated in the Northeast region, while the Midwest region had the least efficient states. It is concluded that, in general, the LPT has been able to achieve both its goals and its objectives.

Keywords: Efficiency. Effectiveness. Rural Electrification. "Luz para Todos" program. Public Policies.

Resumo

O Governo Federal instituiu, em 2003, o Programa "Luz para Todos" (LPT). Por se tratar de uma política pública de relevante impacto socioeconômico e vultuoso investimento governamental, faz-se necessário avaliar seus resultados. Visto isso, objetivou-se avaliar o LPT em termos de eficácia e eficiência. Para tanto, construiu-se um indicador de atendimento de suas metas e aplicou-se um modelo de Análise Envoltória de Dados. Os resultados indicam que grande parte dos estados brasileiros já havia superado a meta de eletrificação até 2014. Dentre as exceções há concentração de estados da região Norte. Por outro lado, os estados mais eficientes estavam concentrados na região Nordeste, enquanto o Centro-Oeste possuía os estados menos eficientes. Conclui-se que, em geral, o LPT tem sido capaz de atingir tanto as suas metas quanto os seus objetivos.

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Palavras-chave: Eficiência. Eficácia. Eletrificação Rural. Programa “Luz para Todos”. Políticas Públicas.

Introduction

Several socio-economic problems faced around the world can only be mitigated or, at best, eradicated, through programs or public policies. In order to achieve socially desired objectives, governmental actions must be correctly formulated and implemented. In Brazil, among so many social problems faced by the population, the lack of access to electricity can be highlighted.

The scarcity of electricity in Brazilian rural households is a reflect of developmentalist view mistakenly adopted in past decades. To overcome this situation, it is necessary to consider the rural environment as a potential alternative source of income and well-being for the population, respecting its peculiar features. This issue becomes even more relevant when the potential benefits related to access and use of electricity are highlighted, such as improvements in education, health, water supply and the performance of domestic tasks. (RUIJVEN; SCHERS; VUUREN, 2012).

As stated by Sen (2000), development should be seen as a way of expanding the real freedoms enjoyed by people, which depend, among other factors, on the provisions of social, economic and civil rights. Among the main forms of freedom deprivation, negligence in the provision of public services stands out. Thus, rural electrification can be configured as a way of guaranteeing essential freedoms for development, since it provides a public service indispensable to the modern way of life, which, as stated by Camargo, Ribeiro e Guerra (2008), is constitutionally guaranteed. Therefore, it is believed that programs aimed at universalizing electricity access are government tools essential for the socioeconomic development of rural areas.

Seen this, the Federal Government of Brazil instituted, through Decree No. 4,873 of November 11, 2003, the National Program for the Universalization of Access and Use of Electricity. Also known as “Luz para Todos” (LPT), the program was designed to provide electricity to the population not yet served, using it as a vector for social and economic development of the benefited communities, thus having a relevant role in reducing poverty. Specifically, the LPT was implemented in order to universalize access to electricity in Brazil, electrifying approximately 2 million households in a situation of energy exclusion prior to the beginning of the program. Over the years, however, an increase in the demand for electrification was noticed, especially in rural areas, which led to the expansion of the original target (IICA, 2011).

The LPT had registered, until 2014, more than 3.6 million connections, at a cost of approximately 16.5 billion reais. Considering the magnitude of these values, as well as the potential social benefits related to the electrification process, the need to monitor the conduction of the program in a systematic way is evident. In fact, as pointed by Frey (2000), evaluating public policies is fundamental to the correction of possible execution flaws and to improve governmental action. The assessment of public policies facilitates the examination of the relationship between the public resources invested in government programs and the fulfillment of goals/objectives initially set.

Seen this, the present research aims to carry out an evaluation of the “Luz para Todos” Program, examining if the program is being conducted effectively and efficiently. In other words, it is proposed to analyze whether the goals set were fulfilled and whether resources are being allocated in a rational way in the pursuit of program’s main objective: to facilitate the social and economic development of the benefited families. To this end, we opted for the construction of an effectiveness indicator and the application of a non-parametric model of efficiency analysis. In principle, two hypotheses are raised. First, it is believed that the LPT was less effective in the states of the North region, due to the predominance of isolated locations, which can hinder the performance of the program. Second, the Southern and Southeastern states are expected to be more efficient, given that the better transport infrastructure and the proximity between urban and rural areas in these regions possibly lessens the need for LPT investments.

In addition to this introduction, the article is organized into four more sections. First, we briefly discuss the connection between access to electricity and rural development. Then, comments are made about the evaluations of effectiveness and efficiency in public policies. Subsequently, the methodology is presented. The next topic, in turn, describes and analyzes the main results found. Finally, the main conclusions are presented.

Electricity, public policies and rural development

Countless are the socioeconomic disparities found around the world. Enphasis can be given to Brazil, where the differences are observed in social macro and micro-territories. It is up to society and the government that represents it to find accessible ways to mitigate these inequalities, providing better living conditions for the citizens. In the case of modern democracies, such actions are expected to be done, supported or led by the State, through policies and programs that enable better quality of life and that boost the development of those socially most vulnerable who, therefore, have greater needs.

In this context, much is discussed about the disparity between urban and rural areas in Brazil, which stems from the intense development that occurred in the first, in the opposite direction to the process that occurred in the second. Historically, the urban environment has been more attractive for both private and public investments. Several factors possibly explain the favoring of urban areas over rural ones, such as greater population density, industrial concentration and, consequently, greater monetary circulation. For example, the privatization process of state-owned companies in the Brazilian electricity sector, which started in the 1990s, can be seen as a major factor in increasing inequality in access to electricity between urban and rural areas, since, unlike urban environment, isolated rural communities are not economically attractive for private organizations to invest in their electrification (SEIFER; TRIGOSO, 2012).

Currently, however, there is a growing number of studies and actions against this movement that prioritizes the urban, where the rural – previously labeled as lagged and isolated – is respected and seen as a "solution bearer" for problems related to unemployment, quality of life and deepening of social relationships (WANDERLEY, 2001). The diverse conceptions related to the rural environment and its features bring up different understandings regarding the theme of rural development. While some think of a strictly economic definition, focusing on improving the conditions of production and income generation, others incorporate social aspects into their definitions.

Diniz and Gerry (2002) highlight a social-political and procedural conceptualization of rural development, in which priority is given to the articulation between people and territories, the empowerment of actors and their active participation in attempts to increase the local quality of life and reduce socioeconomic asymmetries. They also prioritize the possibility of guaranteeing their environmental and economic sustainability and achieving their independence by expanding the range of choices and opportunities generated. In addition, Ellis and Biggs (2001) defend a new concept of rural development in which, along with agriculture, other rural and non-rural activities will emerge as solutions to the existing rural poverty situation, bringing the opportunity to discover new viable and diverse rural livelihoods.

Among the several aspects connected to the development process, which are usually plentiful in urban areas while being scarce in rural ones, the access to electricity worth noting. Dos Santos, Mercedes and Sauer (1999) point out that the deprivation of this service, or its precarious provision, is relevant in increasing inequality in modern societies, and that the negative impacts of this deprivation are concentrated on the most fragile portions of the population like the residents of rural areas, mainly due to the difficulty of access and the low availability of income to assume the costs related to the installation and maintenance of the necessary structure as well as service fees.

Terluin (2003) states that rural development can occur in three ways. First, there is the endogenous development, which usually occurs in rural communities whose local economy is endowed with entrepreneurial characteristics, where its actors work together, improving their activities and increasing their own quality of life. Second, there is the exogenous development, generated through external actions implemented in specific regions through policies aimed at expanding the development of certain locations. Third, there is a mix of the two development models previously mentioned.

The access to electricity, in this sense, is generally pointed out as one of the basic requirements for sustainable development due to the fundamental character of this service for the improvement of social well-being (JOHANSSON; GOLDEMBERG, 2002). Particularly in rural areas, electricity is a fundamental strategy to promote improvements in socioeconomic conditions in developing countries, such as Brazil (SRIVASTAVA; REHMAN, 2006). In general, policies aimed at universalizing electricity access, such as the LPT, have both exogenous and endogenous characteristics, since, based on the electricity-driven improvement of local infrastructure, the rural population would have better conditions to develop by means of their own actions.

It is considered that an exogenous rural development occurs through a response to market failures (PLOEG et al., 2010). Therefore, the need for an exogenous stimulus is considered essential for establishing the basis for the rural development process. This exogenous effort, in the specific case of rural electrification, is even more fundamental, being characterized by State intervention based on the implementation of public policies. Government action through policies focused on universalizing the access to electricity is necessary, given the peculiarities of the electricity market in rural areas.

Peculiarities of the rural areas of developing countries, such as Brazil, make the private provision of electrical services to this environment financially restricted. Most rural communities have a low population density as well as a high percentage of poor households. From this, economically unattractive conditions for the supply of electricity by private means, such as a reduced demand for electricity and the high investments required for the expansion of transmission lines, emerge. Additionally, in most cases, rural households may not be able to afford both installation fees and the relatively high fees that suppliers could charge to cover their costs. (CROUSILLAT; HAMILTON; ANTMANN, 2010).

The endogenous development, in turn, refers to the initiative capacity of rural actors who, according to Ploeg, Ye and Schneider (2015), are guided by realistic strategic plans that, when implemented, may enable the creation of space where changes can continue. Following this idea, there is a believe—associated to the arrival of electricity—that many societies may become able to acquire a higher level of economic sustainability and a better quality of life. Therefore, access to electricity—among other basic requirements such as health and education—can be considered a key element for the socioeconomic development of rural areas and for poverty reduction (PEREIRA; FREITAS; SILVA, 2010).

Evaluation of public policies: efficiency and effectiveness

The idea of evaluating governmental action arose with the reconceptualization of the roles of the State, since the reconstruction initiatives, carried out after the Second World War, led to the adoption of social policies and the need to analyze the costs and advantages of interventions (RUA, 2014). The growing social demands, combined with the scarcity of resources, made evaluation a valuable tool aimed at identifying the best alternative, using resources responsibly (MORRA IMAS; RIST, 2009).

There are many ways to evaluate public policies and programs; they differ in terms of the implementation phase, objectives and who executes them. According to Wollmann (2007), a "classic" evaluation can be directed to analyze whether or not the goals of a policy or program have been achieved (ex-post) or to measure the achievement of the goals (ex-ante). In this case, it is essentially about the effectiveness of policies, measuring the amount of resources invested to reach its objectives.

More specifically, Morra Imas and Rist (2009) highlight the results-based evaluation, for providing reliable and useful information, thus supporting decision making. It evaluates planned, ongoing, or completed interventions, seeking to determine their relevance, efficiency, effectiveness, impact and sustainability. In Brazil, from the 1990s onwards, due to the fiscal crisis and the lack of available resources, the political agenda started to focus on the efficiency and effectiveness of government action, as well as the quality of public services (RUA, 2014).

The effectiveness evaluation allows to answer if a certain project was or will be useful, besides determining which are the main factors responsible for the success or failure of such action (MORRA IMAS; RIST, 2009). Stein et al. (2007), on the other hand, categorize efficiency as a key feature of public policies, given that State's investment should favor activities with greater socioeconomic returns. The efficiency evaluation allows to observe the extent to which an action uses its resources in the least costly way possible to achieve the desired results (MORRA IMAS; RIST, 2009).

Methodology

Electrification Compliance Index

In order to measure the effectiveness of the LPT at the state level, it was decided to elaborate the Electrification Compliance Index (ECI). Specifically, the measure of effectiveness of LPT in state i is given by

$$ECI_i = \frac{TC_i}{CG_i} \quad (2)$$

in which TC_i denotes the total number of connections made through the LPT in the state i between 2004 e 2014; e CG_i denotes the connection goal established for the state i.

The idea behind the ECI calculation lies in comparing the goal set by the government with the number of connections that were actually made within the scope of the LPT. Therefore, it becomes possible to analyze whether the states have actually reached the previously established goals and not merely observe the total number of connections.

Data Envelopment Analysis

In the present study, each Brazilian state was considered as a Decision-Making Unit (DMU). In summary, the Data Envelopment Analysis (DEA) model admits that each DMU transforms N inputs into M products. Here, we consider that N = 1 (average investment per connection) and M = 2 (variation in the average consumption of electricity in rural areas; variation in the rural electrification rate).

The DEA model applied follows an output orientation. As a social policy is being analyzed, it is believed that the volume of resources allocated to it will not be reduced indiscriminately, but that it will seek to achieve better results with a given level of investment. Therefore, the efficiency of the LPT is evaluated in terms of how the states could make more connections with the same level of investment.

The estimated model is represented by the following equation:

$$D_O^{Sh}(x_i, y_i) = \inf_{\theta}\left\{\theta > 0 : \left(x_i, \frac{y_i}{\theta}\right) \in S\right\}, \quad (1)$$

in which $D_O^{Sh}(\cdot)$ denotes the product-oriented Shepard distance; x_i e y_i denote, respectively, the inputs used and the products generated by DMU i; θ denotes the efficiency scores, with $0 < \theta < 1$ for inefficient DMUs and $\theta = 1$ for efficient DMUs.

The nature of the return to scale is determined using the test proposed by Simar and Wilson (2002), in which the null hypothesis that returns to scale are constant is tested. Specifically, equation 1 is estimated through the procedure proposed by Simar and Wilson (1998, 2000), given the possibility of obtaining, via bootstrap, the bias associated with the application of the traditional DEA model and, therefore, the corrected efficiency scores.

Data

The analyzes are carried out at the state level, considering that this is the lowest level of aggregation for which data related to the execution of the LPT are available. Specifically, 26 federation units are considered. The Federal District is not included in the sample due to its high levels of urbanization and access to electricity. Its consideration could generate a bias in the calculation of program's efficiency.

Connection targets were originally defined by the Federal Government in the Normative Resolution No. 175 (ANEEL, 2005). However, it was subsequently expanded through the Normative Resolution No. 365 (ANEEL, 2009) and these are the values used here. The norm defines individual goals for each concessionaire and permissionaire of electricity distribution, so that the state goals were calculated by the sum of the goals defined for the electricity distributors operating at each federative unit.

The total number of connections made through the LPT between 2004 and 2014, as well as the amounts invested for that purpose, were obtained from the Brazilian Open Data Portal. The percentage of rural households electrified in 2004 and 2014 was extracted from the National Household Sample Survey (PNAD) through the IBGE Automatic Recovery System (SIDRA). The number of consumer units and the consumption of electricity in rural areas were taken from the Statistical Yearbook of Electric Energy, published by the Energy Research Company (EPE).

Results

Effectiveness

The effectiveness of each federative unit in meeting the goals established by the LPT is shown in Table 1. It is noteworthy that 20 of the 26 Brazilian states present values above the unit for the ECI. That is, the previously defined goal was exceeded for all these units of analysis. A plausible justification for this situation lies in the fact that, after the expansion of the connections goal by the ANEEL in 2009, there was an expansion in the number of households without access to electricity in these states, which also ended up being attended by the program.

In addition, the data used does not specify the category of connections. The LPT also serves schools, settlements and indigenous and quilombola populations.

Among the states with an ECI greater than one, we highlight those in which the number of connections was more than twice the target: Espírito Santo, Santa Catarina, Rio de Janeiro and Minas Gerais. It is clear that these states are located in the most developed regions of the country and that, for this reason, they have comparatively better infrastructure conditions. Therefore, one could relate the high number of connections to the easier operation of LPT teams in both logistical and operational terms.

Table 1: Luz Para Todos Program's Electrification Compliance Index, by brazilian states, 2004-2014.

Ranking	State	Effectiveness	Ranking	State	Effectiveness
1	ES	2,26	14	CE	1,23
2	SC	2,14	15	AL	1,17
3	RJ	2,12	16	PA	1,10
4	MG	2,04	17	MA	1,08
5	SE	1,74	18	PB	1,06
6	RS	1,60	19	RO	1,05
7	SP	1,58	20	TO	1,00
8	MT	1,51	21	AM	0,94
9	MS	1,44	22	GO	0,92
10	RN	1,40	23	RR	0,85
11	BA	1,25	24	PI	0,77
12	PE	1,25	25	AC	0,66
13	PR	1,24	26	AP	0,62

Source: Research results.

On the other hand, the state with the worst indicator was Amapá. Among those that presented values below the unit, the states of Acre and Piauí can also be highlighted. In general, it is noticed that the least effective states were concentrated in the North-Northeast of Brazil. In fact, with the exception of Goiás, the states that did not reach the electrification target by 2014 are located in the North (Amapá, Acre, Amazonas and Roraima) and in the Northeast (Piauí). This outlook may be closely related to the fact that these states—especially those located in the North region—have municipalities with a high territorial extension, which, added to the low demographic density, interferes negatively in the conduction of connections promoted by the LPT (SLOUGH; URPELAINEN; YANG, 2015).

In order to complement the analysis of the results obtained for the ECI, Table 2 shows the evolution of access to electricity in rural areas of Brazilian states between the years 2004 and 2014. It is clearly observed that the rural electrification process evolved significantly for all states in that period. Although it is not possible to assert that this evolution has its exclusive origin in the LPT, it is plausible to consider that the program was responsible for a large part of this progress.

Table 2: Access to electricity in rural areas of Brazilian states, in percentage terms, 2004 and 2014.

State	Rural electrification		State	Rural electrification	
	2004	2014		2004	2014
ES	98,16	100,00	CE	81,59	99,58
SC	98,99	99,46	AL	87,60	99,22
RJ	99,33	100,00	PA	60,67	94,12
MG	88,24	99,15	MA	53,78	98,65
SE	80,65	98,45	PB	94,00	100,00
RS	95,23	99,51	RO	76,92	98,50
SP	99,04	99,58	TO	47,92	95,45
MT	72,43	97,85	AM	61,73	77,58
MS	92,31	98,97	GO	89,15	99,01
RN	89,50	99,59	RR	60,87	96,00
BA	67,98	96,29	PI	66,67	92,88
PE	89,90	99,62	AC	48,94	83,64
PR	92,89	99,78	AP	69,23	100,00

Source: SIDRA.

It can be seen, from the analysis of Table 2, that the vast majority of Brazilian states already had, in 2014, more than 95% of their rural households with access to electricity. In fact, only four of the twenty-six states analyzed were below this threshold. They are Pará, Acre and Amazonas, in the North, and Piauí, in the Northeast. On the other hand, it is emphasized that the rural areas of all states in the South and Southeast regions were already electrified[4], in view of the observation of rates above 99%.

Among the states that, until 2014, did not meet the goal established by the ANEEL, the cases of Goiás and Amapá stand out. Both states had an electrification rate higher than 99%, indicating that even if the goal of connections has not been reached, the objective of bringing electricity to all of their rural households has been completed. However, a question remains: what is the cause of the mismatch between these values? It is believed that, especially for the state of Amapá, the rural exodus is largely responsible for this panorama.

Together, Tables 1 and 2 indicate that, in general, the least effective states were those that had the lowest rural electrification rates in 2004. Although, as explained above, these states have also evolved in terms of electrification, some of them still remained as the lowest levels of access to electricity in 2014, especially those located in northern Brazil. Considering that the inhabitants of these states are those with the lowest levels of development, the government has been looking for alternative solutions to expand access to electricity in this region (GÓMEZ; SILVEIRA, 2010).

Taking only the results achieved by ECI into account, it is possible to state that the LPT was, in fact, effective in most Brazilian states, as the vast majority of them presented values above the unit. When the data presented in Tables 1 and 2 are contrasted, it can be observed that the rural areas of several states were universally electrified, which was observed even for some of the less effective states in terms of the LPT performance.

Efficiency

Descriptive statistics of the variables of the efficiency model are presented in Table 3. The average cost of LPT connections exceeded R$4,600.00, which comprises the investments made in the acquisition of transmission cables, light poles and transformers. However, there is an expressive amplitude in these values. Indeed, while the highest average cost was around R$9,300.00 (Amapá), the lowest was approximately R$2,700.00 (Santa Catarina). There is also a wide dispersion in the values, considering that the calculated standard deviation corresponds to almost one third of the average.

Regarding the outcomes of the DEA model, it is evident that there was, on average, an increase of slightly 20% in the average consumption of electricity in rural areas. It should be noted, however, that seven states showed a drop in such value. In Amapá, for example, there was a decrease of more than 35% in the average consumption. While total consumption remained stable in this state during the analyzed period, the number of consumer units increased by more than 50%. In the

[4] Normative Resolution No. 488 (ANEEL, 2012) defines that locations with an electrification level greater than 99% have, at least in technical terms, universal access to electricity.

opposite direction, the state of Maranhão registered an increase of more than 120% thanks to a significant increase in total consumption and a decrease in consumer units.

Table 3: Descriptive statistics of DEA model's variables.

Variable	Mean	SD	Max.	Min.
Input				
Average investment per connection (1.000 R$)	4,69	1,44	9,37	2,70
Output				
Variation in average rural electricity consumption	1,21	0,34	2,23	0,63
Variation in rural electrification rate	1,27	0,27	1,99	1,00

Source: Research results.

The variation in the electrification rate, on the other hand, showed different results. All Brazilian states presented a positive evolution, although there was great variability in these values. While Tocantins practically doubled access to electricity in its rural areas, this rate remained relatively constant in states like Santa Catarina, São Paulo and Rio de Janeiro. However, all of them already had more than 99% of their rural households electrified in 2004. In Brazil, on average, the rural electrification rate in 2014 was 27% higher than that observed in 2004.

Efficiency scores calculated using the output-oriented DEA with constant returns to scale are shown in Table 4. The states (DMUs) are ranked in decreasing order according to the corrected efficiency level. At first, considering the efficiency scores without correction, only Rio Grande do Norte and Santa Catarina were classified as efficient by the model. However, when considering the corrected scores, it is evident the magnitude that the bias associated with the traditional DEA model can achieve. For example, the correction via bootstrap makes Santa Catarina present only the ninth highest efficiency among the units analyzed.

Among the ten most efficient DMUs, there is a predominance of states located in the Northeast region. Thus, it can be observed that the LPT showed great efficiency in conducting electrical connections in one of the regions that presents the highest demand for electrification in the country. With the exception of Maranhão, the northeastern states classified among the most efficient DMUs had an average connection cost below the national average. In addition, most of them achieved above-average increases in the mean consumption of electricity in rural areas and the electrification rate.

Table 4: Output oriented DEA bootstrap model with constant returns to scale, Brazilian states.

Ranking	State	Efficiency	Corrected Efficiency	Ranking	State	Efficiency	Corrected Efficiency
1	RN	1,00	0,98	14	RJ	0,76	0,74
2	PE	0,98	0,95	15	PB	0,74	0,73
3	MA	0,99	0,93	16	SP	0,76	0,72
4	SE	0,93	0,91	17	AC	0,68	0,66
5	PI	0,94	0,91	18	RO	0,67	0,65
6	CE	0,93	0,91	19	AL	0,66	0,64
7	BA	0,87	0,84	20	AM	0,64	0,62
8	TO	0,85	0,83	21	ES	0,60	0,57
9	SC	1,00	0,81	22	GO	0,58	0,55
10	PA	0,81	0,79	23	RS	0,60	0,55
11	MG	0,83	0,79	24	MT	0,55	0,54
12	RR	0,80	0,79	25	MS	0,47	0,46
13	PR	0,82	0,76	26	AP	0,41	0,40

Source: Research results.

On the other hand, there is a large concentration of states of the North and, mainly, Center-West regions among the ten least efficient DMUs. In addition, in general, they did not show a significant increase in access and use of electricity in rural areas, these states accounted for the highest connection costs in the sample. The low efficiency achieved by the states in these regions may be linked to operational and logistical issues, such as the geographical dispersion of rural properties and the predominance of isolated locations.

Given the apparent geographic concentration of LPT's efficiency, it was decided to investigate the results of the DEA model in an aggregate way. In this sense, Table 5 presents the descriptive statistics of the bias-corrected efficiency scores for the Brazilian regions. The geographic concentration of efficiency is evident, due to the higher average efficiency presented by the Northeast region. In a second group are the North, Southeast and South regions, with relatively close values. The Center-west, in turn, has the lowest average efficiency.

Table 5: Descriptive statistics of bias-corrected efficiency scores estimated by an output-oriented, bootstrapped DEA model with constant returns to scale, results aggregated by geographical region.

Region	Mean	Standard deviation	Maximum	Minimum
North	0,68	0,14	0,83	0,40
Northeast	0,86	0,11	0,98	0,64
Southeast	0,70	0,09	0,79	0,57
South	0,71	0,11	0,81	0,55
Cener-west	0,52	0,04	0,55	0,46

Source: Research results.

In order to corroborate the results presented in Table 5, it was decided to test the existence of statistical differences between group means. It was proved, through a simple analysis of variance, that the efficiency averages obtained for each region are statistically different, as the F test presented a p-value of 0.0030. Going further, the means were compared two by two using the Tukey test. Statistical differences were found only between the Northeast region and the North and Center-west regions.

Conclusions

The present study sought to evaluate the effectiveness and the efficiency of the "Luz para Todos" Program in the Brazilian states from 2004 to 2014. To do so, an effectiveness index, the Electrification Compliance Index, was developed, and, additionally, an output-oriented bootstrap DEA model with variable returns to scale was applied.

The hypothesis raised about the effectiveness of Luz para Todos was confirmed. It was evidenced that, in general, the states located in the North region had the lowest effectiveness indicators. In fact, Amazonas, Roraima, Acre and Amapá did not achieve, until 2014, the goal of connections established for the program. These results can be justified by the large territorial dispersion of rural households as well as the lack of logistics infrastructure, which considerably increase the cost of connections. There is also the issue of isolated communities, for which the supply of electricity becomes even more complex.

It is worth highlighting, however, that the failure to meet the goals set by the Federal Government for the LPT cannot be directly translated into an inability to promote rural electrification in these states. For example, Amapá—which was the state with the lowest efficiency rate—already had 100% of its rural households with access to electricity in 2014. It is believed that this fact may be associated with rural exodus, which ultimately leads to a decrease in the demand for rural electrification. However, it should be noted that other states in the region, such as Amazonas and Acre, were still far from the main objective of the LPT—universal access and use of electricity. Therefore, future research could be dedicated to explain the different evolution of the rural electrification process within specific regions.

On the other hand, the hypothesis established for the efficiency of the program was rejected. Among the ten most efficient states, nine are located in the North and Northeast regions, which goes against what was initially expected. It is also noteworthy that the seven highest corrected efficiency scores were obtained by northeastern states. In this case, it is evident how efficient the LPT was in the region that historically presented one of the greatest demands for rural electrification. In addition, it is necessary to highlight that despite having low efficiency, some states had high levels of electrification. The main example is Amapá which, despite presenting the lowest efficiency level, had already universalized access to electricity in its territory in 2014.

It is possible to conclude that the Luz para Todos program, in fact, proved to be effective for most of the Brazilian states. However, the Federal Government must pay attention to those states whose numbers of connections were below the stipulated target. In this case, the states of Acre and Amazonas stand out, which still had less than 90% of their rural households with access to electricity in 2014. On the other hand, the concentration of more efficient states in the North and, especially, the Northeast is an indicator that the resources are being used correctly and with quality. It is also worth noting the observation of states in which there was a drop in average electricity consumption in rural areas despite the evolution of the program.

This scenario justifies the investment in government programs that complement LPT's performance, allowing beneficiaries to purchase household consumer goods and productive equipment. On the one hand, the LPT can, in fact, be seen as the exogenous stimulus necessary for neglected populations to have access to electricity and, thus, facilitate local development. On the other hand, complementary government programs – such as rural extension, subsidized credit or conditional cash transfer – can enhance the benefits related to electrification, enabling the endogenous development of the beneficiary population in order to achieve a higher level of economic sustainability and better quality of life.

Ultimately, considering both the effectiveness and efficiency indicators, one could say that the LPT has, in fact, been acting as a development vector for communities assisted by the electrification process. As highlighted in the literature, it was observed that the biggest obstacle to an even greater advance of the LPT continues to be the difficulty in offering electricity to isolated communities that inhabit more remote areas of the Amazon region. It should be noted, however, that, seeking not to exclude such locations from the development process guided by access to electricity, the Brazilian government has been investing in alternative solutions, with emphasis on renewable technologies.

Despite the important findings provided by this research, some deficiencies should be highlighted. First, the data made available for consultation only go up to 2014, making a more recent analysis unfeasible. Second, the data provided by the Federal Government do not allow the identification of the LPT beneficiaries' characteristics. It is impossible, therefore, to determine whether they already lived in rural areas before the implementation of the program or whether they returned to the countryside precisely because of the provision of electricity. Third, the investments made for the Luz para Todos program come from different sources, which, if data were available, would enable the conduction of a more detailed analysis, especially regarding the efficiency analysis. Finally, it is believed that future research with a more detailed focus on the North and Northeast regions of Brazil—those with the largest number of connections made by the LPT—could help to better understand the program's evolution and results.

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