A brighter future: The impact of rural school electrification programs on the dropout rate in primary education in Brazil

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Abstract

School electrification can decrease the gap between rural and urban education. The Brazilian policy focusing on electricity access in school decreased student's dropout rate. Rural electrification programs – like the Light for All – have been successful to increase access to electricity services in Brazil, where 99.3% of the population has access to it. On the public policy viewpoint, the cost-benefit analysis must consider not only the direct impact of the programs but also the positive externalities of it. In this paper, we aim to study the Light for All in Schools (LFAS, "Luz para Todos nas Escolas"), a program focused on providing access to electricity to rural schools. The study aims to measure the effect of access to electricity in rural schools on the dropout rate of students in primary education. Our goal is to create a dialogue between the studies on the benefits of electricity in vulnerable areas and the studies on education outcomes. Our results show that electrification programs, like the LFAS, have a significant effect on the dropout rate of rural schools. Schools that received electricity by the program before 2013 had an improvement of 16% in the dropout rate in 3 years, and schools that were treated by the program between 2013 and 2016 had an improvement of 27% in 3 years due to the access to electricity.

Key-words: School dropout; Rural education; rural electrification; Brazil.

Resumo

A eletrificação rural pode reduzir o hiato entre a educação rural e urbana. A política brasileira de educação rural nas escolas reduziu a taxa de abandono dos alunos. Programas de eletrificação rural - como o Luz para Todos - foram bem sucedidos em aumentar os serviços de eletricidade no Brasil, onde 99,3% da população possui acesso. Do ponto de vista das políticas, a análise de custo-benefício deve considerar não apenas os impactos diretos dos programas, mas também as externalidades positivas destes. Neste artigo, nós focamos no estudo do Luz para Todos nas Escolas (LPTE), um programa voltado à provisão de eletricidade às escolas rurais. Este estudo busca mensurar o efeito do acesso à eletricidade nas escolas rurais sobre a taxa de abandono escolar na educação primária. Nosso objetivo é criar um diálogo entre os estudos que apontam os benefícios do acesso à eletricidade em áreas vulneráveis e os estudos sobre desempenho educacional. Nossos resultados indicam que programas de eletrificação, como o LPTE, têm um efeito significativo sobre a taxa de abandono das escolas rurais. Escolas que receberam eletricidade pelo programa antes de 2013 tiveram uma melhoria de 16% na taxa de abandono escolar em 3 anos, e escolas que foram tratadas pelo programa entre 2013 e 2016 tiveram uma melhoria de 27% em 3 anos.

Palavras-Chave: Abandono escolar; Educação rural; Eletrificação rural; Brasil.

JEL: Q41, Q48, I24

Área 12 - Economia Social e Demografia Econômica

1. Introduction

The universal access to energy became one of the 17 Millennium Development Goal of the United Nations in 2015. Energy access was recognized as a key element for improving socio-economic conditions in developing countries. The access of the energy services is expected to have a multi-dimensional impact on the potential of socio-economic development of a region, changing productivity, education and health. Even if this relation is intuitive, the evidence of the impact of energy access in the householder’s welbeing is still a challenge (see for instance, Bharracharyya, 2012).

There is an effort in the literature looking to measure these evidences. For instance, Dinkelman (2011) show positive impact on employment for South Africa, Khandker et al. (2012) shows the impact of access in the decreasing of poverty in India. Lipscomb et al. (2013) find evidence in Brazil of positive effects of electrification on development index by looking at long term trends (1960-2000). There is overall positive impact of energy access, however, great differences among cases (JIMENEZ, 2017). To find measurable evidences is relevant in the process to estimate the benefices of access policies and to improve the design of these policies. Our study contributes to this literature by showing evidence of the impact of school energy access in rural education in Brazil.

Electricity access in Brazil reaches 99.3% of the population OLADE (2017). Nonetheless, isolated rural areas still suffer from the lack of electricity benefits, such as lighting and refrigeration. This “last mile” problem excludes a small but extremely vulnerable share of the Brazilian population, like poor rural communities from the semi-arid region, Amazon riverside (also known as “*ribeirinhos*”) and indigenous communities, and *quilombos* (century-old settlements founded by people of African origin who escaped from slavery).

Education is important due to many reasons. It has individual and collective socioeconomics benefits. It is one of the main determinants of individual income, which means it also has an essential role in income inequality (Belfield, 2000). Inequalities of educational opportunities result in income disparities due to the small likelihood of the poorest reaching secondary and higher education (especially the latter), impairing the reduction of income inequality (Ney, Souza and Ponciano, 2010). Promoting basic education in a country like Brazil, with a strong presence of inequality and poverty, is a necessary condition for the full exercise of citizenship and participation in a modern economy.

Teixeira e Menezes-Filho (2012), using a Mincer equation with an instrumental variable approach and data from 1997 to 2007, estimate that a year of schooling in primary education increases an individual's wage in 5.5% in Brazil. Although this figure might seem low, we should have in mind that in 2007, 95% of children aged 6 to 14 were enrolled in primary education.[1] An additional year of higher education, for instance, has a greater impact on wages.

That being said, the mean years of schooling in the sample used by the authors is eight years. In 2015, the mean years of schooling for rural areas was 5.3, while in urban areas that figure goes up to 8.3 (PNAD, 2017).[2] In addition, estimating a Mincer equation for a rural area is complex due to inherent characteristics, such as the seasonal nature of rural wages. Considering all this, the returns to primary education in rural areas is likely higher than 5.5%.

Since 1988, the Brazilian Federal Constitution establishes education as a social right with universal access to all grades of basic education (primary and secondary education). Therefore, isolated communities have the constitutional right to claim access to regular education in a public school. However, the infrastructure of these schools is precarious (Pieri e Santos, 2014). These schools usually lack access to basic services, such as drinkable water and electricity access. The absence of these services may affect the daily life of the school

[1] Observatório do PNE. 2 - Ensino Fundamental. Retrieved from http://www.observatoriodopne.org.br/metas-pne/2-ensino-fundamental.

[2] Considering the population aged 10 years or more.

community, including the attainment of schools' levels. As of 2017, 65.3% of the 16-year-old rural population had at least concluded primary education. While that number has steadfastly increased since 2012, it is still 12,7 p.p. less than the urban figure, 78% (Inep, 2018).

Particularly, the effects of electricity on learning are directly related to the availability of artificial lighting. The benefits of it are innumerous. It can affect school performance indirectly through improvement of infrastructure, such as water treatment, sanitation, heating, and cooling. Direct effects might occur via children being able to read and write better and increased concentration and motivation. Artificial lighting extends possible teaching and studying hours, which is important in rural areas where students usually work on family farms during the daytime.

Further, electrification might increase schools' attractiveness and encourage attendance. For instance, one study found that electrification increased the likelihood of having a secondary school degree in Peru and Ghana (Welland, 2018). It might also increase teacher quantity and quality, given that rural schools have greater difficulty attracting and retaining (good) teachers. Energy access can also enable the use of computers and other ICT (information and communication technologies) and the use of school's buildings for adult literacy in the evenings (Welland, 2018).

In fact, appropriate lighting seems to have positive returns on learning. For instance, Dunn et al. (1985) found that children that feel more comfortable under light perform better with a brighter ambient. Sleegers et al. (2012) showed that an adequate lighting system has positive effects on the concentration of pupils. Further, electrification might increase schools' attractiveness and encourage attendance. Moreover, the electrification of schools may also have positive externalities for communities, such as water and sanitation and resilience to natural disasters (Welland, 2018). Diniz et al. (2006) report a decrease in illiteracy and improvement in educational opportunities in poor municipalities in Minas Gerais state, which participated in a rural school electrification program.

Despite great improvement in the last decade, school dropout remains a relevant issue, especially for rural schools. Dropout rates are much higher among poorer families (Leon and Menezes-Filho, 2002; Ney, Souza and Ponciano, 2010), working students (Leon and Menezes-Filho, 2002; Verner and Cardoso, 2007) and low-performance students (Leon and Menezes-Filho, 2002) in Brazil. These three elements match the profile of rural communities attended by the Light for All program (*Programa Luz para Todos*, in Portuguese). The program aims to "provide free access to electricity to rural families" (our translation), in particular to rural schools, *quilombos*, *ribeirinhos* and small farmers. The Light for All program in itself seems to have benefits on education outcomes. Using a regression discontinuity design, Cajiao (2018) show an positive and significant impact of energy access through the program on approval rates and Portuguese and Mathematics test scores for children in the 5th and 9th year of primary education.

The branch of LFA focused on schools is the Light for All in School (*Luz para Todos na Escola*, in Portuguese), that provides electricity to schools without access to electricity. As mentioned above, electricity has many potential returns to education, including learning and school dropout, which LFAS expects to improve.

This study aims to measure the effect of access to electricity in rural schools on the dropout rate of students in the first five years of primary education. Our goal is to create a dialogue between the studies on the benefits of electricity in vulnerable areas and the studies on education outcomes, contributing to this growing research area. We hope that our research helps to clarify the social returns of electricity provision to vulnerable rural regions and the impact on the education outcomes.

We employ a differences-in-differences approach (DD) on a two-year panel of schools (2013 and 2016). Our results show that the Light for All in Schools program has a significant effect on the dropout rate of rural schools. Specifically, schools that received electricity by the program before 2013 had an improvement of 16% in the dropout rate in 3 years, and schools that were treated by the program between 2013 and 2016 had an improvement of 27% in 3 years due to the access to electricity.

This result contributes as evidence that a proper infrastructure to teach and learn in initial years of schooling has an important role to retain children in schools and to, potentially, reduce child labor. Moreover, the gains that programs like the Light for All in Schools have to rural areas help to reduce inequality, first, reducing the educational gap between areas with different urbanization levels and, second, providing a higher capacitated human capital to less-developed regions.

2. School dropout and socioeconomic context in rural areas

Both literature and policy-making use scores from standardized tests to evaluate the effectiveness of schools. However, maximizing student learning, defined by specific metrics captured by these tests, may not be the only goal pursued by a school or an education system. These goals are defined by societies and can be multiple and interchangeable. Rumberger and Palardy (2005) argue that using only standardized tests provides an incomplete view of school performance and may result in erroneous conclusions about which schools are effective and which characteristics promote effectiveness.

Given that most of the national literature uses standardized test results (Felicio, 2008), using alternative indices is relevant because it encompasses other school aims (Rumberger and Palardy, 2005). For example, ensuring that students complete their education can be as important as improving their academic performance (Rumberger and Palardy, 2005). School attendance and dropout present different trends throughout basic education and in urban and rural settings. Data from the 2010 Demographic Census show an overrepresentation: although only 18.6% of the population aged 4 to 17 years old live in rural areas, 27% of those out of school live in rural areas (Alves and Silva, 2013). As Table 1 shows, despite its decrease between 2007 and 2017, schools' dropout rate is still higher in rural areas in 2017. Moreover, the decrease between the two years was steeper in urban schools.

Table 1. Dropout rates by stage of basic education and area - Brazil, 2007 and 2017

	2007		2017	
	Primary Education	Secondary Education	Primary Education	Secondary Education
All areas	4.8	13.2	1.6	6.1
Urban	4.4	13.2	1.4	6.1
Rural	6.9	14	2.9	7.5

Source: Own elaboration with data from Inep.[3]

Basic education in Brazil is divided into three stages: i) child education (children between 0 and 5 years old); ii) primary education covers 9 years (children between 6 and 14 years old); and, iii) secondary has a minimum duration of three years (young people between 15 and 17 years old). While primary education has been compulsory since 1971, secondary education only became mandatory in 2009 by Constitutional Amendment n. 59 (Alves and Silva, 2013).

[3] National Institute of Educational Studies and Researches Anísio Teixeira (Inep). *Indicadores educacionais*. Retrieved 23 October 2018 from http://portal.inep.gov.br/web/guest/indicadores-educacionais.

Aware of the differences in socioeconomic matters between urban and rural areas, most researches tend to study urban and rural schools separately. In fact, since only 11% of basic education students are enrolled in rural schools, rural education has received less focus in the Brazilian literature.[4] Given this and the data discussed above, it is reasonable to assume that school attendance and dropout are different phenomena for different education stages and geographic areas. Moving forward, we focus on our object of study, which is rural schools providing the first years of primary education (first to fifth year, children between 6 and 10 years old).

In general, schools and classes are smaller in rural education, and there is a need to provide transport to students and teachers. Thus, the cost per student in rural education is higher than in urban schools (Alves and Silva, 2013). Rural areas have higher poverty levels, adults have fewer years of schooling, and public services are provided at a lower quality. Problems of intergenerational poverty are persistent and worsened by the inequality of educational opportunities (Ney, Souza and Ponciano, 2010).

With data from the National Household Sample Survey (in Portuguese, *Pesquisa Nacional por Amostra de Domicílios* - PNAD) from 2007, Ney, Souza and Ponciano (2010) analyzed primary education conclusion in urban and rural areas. In both geographic areas, school dropout occurs mainly from the fourth year onward, and it is highest for the poorest (below 40% in the income distribution).[5] Even so, dropout is highest in rural than in urban areas in all of primary education. Parents with low education level are probably unaware of the import role education plays in social ascension. Considering how high inequality in educational opportunities is in rural areas, intergenerational poverty tends to be more intensely reproduced (Ney, Souza and Ponciano, 2010; Kassouf, 2015).

Moreover, there is the enduring problem of child labor. In 2015, 97 thousand children between the ages of 6 and 10 were working. Of those, 72 thousand lived in rural areas. That amounts to 2.6% of children living in rural area in this age group (PNAD, 2017). Kassouf (2015) argues that rural areas are more susceptible to child labor due to its higher levels of poverty and worse school infrastructure and a lower rate of technological innovation, which might discourage school attendance. Likewise, the higher prevalence of informal jobs and family agricultural works are also responsible for facilitating child labor.

The consequences of child labor are many and multidimensional. It impairs on a person's ability to acquire education and invest in human capital reducing school attendance and performance. In its turn, low schooling and poor education achievement will limit employment opportunities to positions with no qualification requirements and low remuneration, keeping the person in the cycle of poverty already experienced by their parents (Kassouf, 2015).

Discussing the solutions to child labor, Kassouf (2015) highlights the importance of improving access to quality education, especially in poorest and hard-to-reach regions and for children in vulnerable situations. It is also essential to ensure the completion of (at least) basic education.

3. The Light for All in Schools program in Brazil

The program Light for All (LFA) was created in 2003 through an executive order[6] (EO) and is officially called "National Program for the Universalization of Electric Energy Access and Usage – Light for All". The program was originally supposed to operate from 2003 to 2010 but was expanded by four consecutive EOs (2008, 2010, 2011, 2014 and 2018) until 2022.

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[4] National Institute of Educational Studies and Researches Anísio Teixeira (Inep). *Statistics Synopsis of Basic Education*. Retrieved 23 October 2018 from http://portal.inep.gov.br/web/guest/sinopses-estatisticas-da-educacao-basica.

[5] Primary education is divided between first years (1 - 5) and final years (6 - 9). Other studies (Leon and Menezes-Filho, 2002) also verify a higher dropout rate at the end of an education cycle.

[6] Executive Order number 4,873 / 2003.

According to the Ministry of Mines and Energy, 16.4 million people received electricity in their home from 2004 to 2017. On its premise and goal, the EO (2011) states that "[*the program*] intends to allow the access to electric energy to the share of rural population which does not have access to this public service" (our translation).

In its fifth article, the EO (2003) establishes as a priority "projects of rural electrification of public schools (…)", from which derived the program supplement named Light for All in Schools (LFAS). Although schools are one priority of the program, they are below (a) rural houses below the poverty line, (b) houses within cities without basic living infrastructures and (c) rural familiar settlements, indigenous communities, *quilombos*, and other small communities.

In Figure 1 we draw the scheme of operation of the program. The program is organized in four hierarchical levels: (1) coordination, (2) operation, (3) schools assessment and (4) execution. The Ministry of Mines and Energy (MME) of Brazil coordinates the program and is responsible for defining goals and deadlines. The operation is the responsibility of Eletrobras and its subsidiaries[7]. The Ministry of Education is responsible for evaluating the schools without access to electric energy during the yearly school census. Then, Eletrobras informs local management committees which schools do not have access to energy. Local Commissions demands local executors (power concessionaires) to provide electricity access. Power concessionaires elaborate a work schedule for energy provision, which is approved by Eletrobras, and execute the connection of the schools. Both the National Management Committee for Universalization and the Brazilian electricity regulatory agency (ANEEL) assess the program performance.

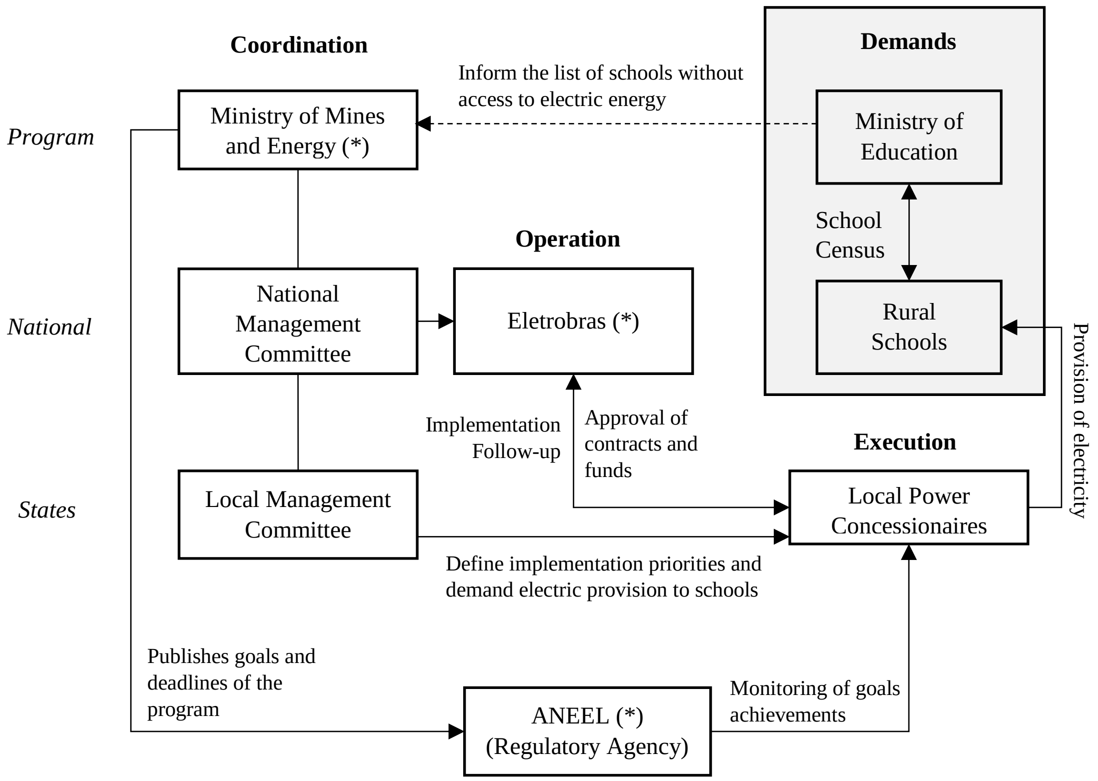
The LFA projects can have three sources of funding: (i) subventions, (ii) public financing and (iii) local concessionaires' own resources. The subvention is a direct transfer from two sources, the "Energy Development Account"8 (CDE) and the "Global Reversion Reserve"9 (RGR), to local executors in order to mitigate regional deficiencies of funds or tariffs impacts. The public financing is a contract available to local executors by *Caixa Econômica Federal* (CAIXA, a government-owned bank) with technical supervision of Eletrobras. The total cost of the program financed by the CDE, RGR, and CAIXA was BRL 9.87 billion (deflated by the Consumer's Price Index up to 2017), as reported by the MME in 2017 (BRL 608.71 per person or 2911.62 per family connected).

[7] Eletrobras is a mixed public-private company, with operations on electricity distribution, transmission and generation.

[8] In 2002, the Energy Development Account (CDE, in Portuguese: *Conta de Desenvolvimento Energético*) is created aiming the energy development of states and competitiveness of power generation of wind, small hydro, biomass, natural gas and coal. In particular, the CDE creation aimed the universalization of electricity. Latter, an Executive Order (EO 4521) provided a guideline to the source of funds and using of the CDE.

[9] The Global Reversion Reserve (RGR, in Portuguese, "Reserva Global de Reversão") was created in 1957 by the EO 41,019 and aims the expansion and quality improvement of the public provision of electric energy. The reserve comes from sector charges payed by power concessionaires with an aliquot of 2.5% of the fixet asset of the company, with a cap of 3% of the revenues.

Figure 1. Operational Flow Chart of Light for All in Schools



(*) Members of the National Management Committee for Universalization
Source: Our elaboration based on the "Manual of Operation" (2015) and information provided by the Ministry of Mines and Energy

From a technical perspective, Power Concessionaires may provide electricity on-grid (connecting the school) or off-grid (by providing microgeneration facilities). The program operation manual gives five options of decentralized power generation: (i) micro hydro (< 100 kW) or mini hydro (from 100 kW to 1 MW), (ii) small hydro (from 1 MW to 30 MW), (iii) small thermal power station (diesel or biomass), (iv) solar or wind micro-generation, (v) hybrid system combining previous options.

Thus, the program governance, operation, and financing follow a very complex scheme, with many decision levels and many ways to calculate the costs and benefits of the electrification. The benefits of the Light for All projects, like the LFAS, are still being evaluated. This paper aims to fill this gap in the literature by highlighting the benefits the LFAS bring to rural education.

4. Methodology

4.1. Data description

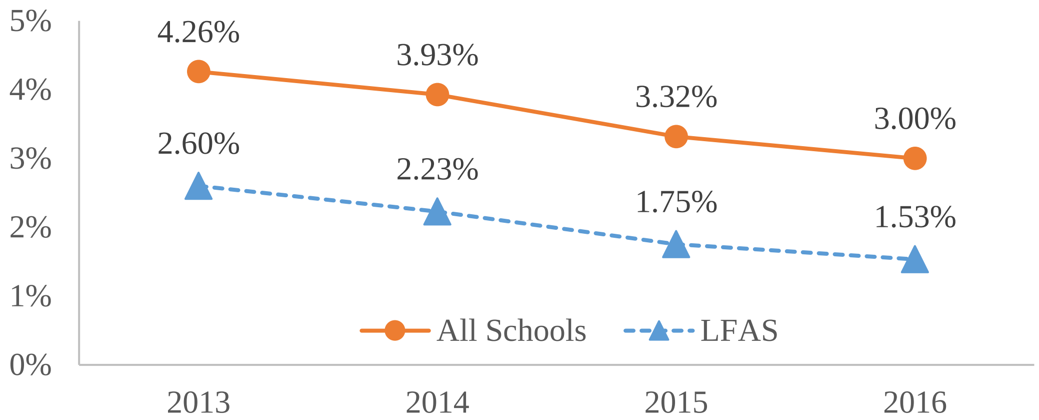
The database used was a panel of schools constructed with two datasets: School Census of Basic Education, from the Ministry of Education of Brazil (MEC), and the Light for All in Schools (LFAS) list of participants, from the Ministry of Mines and Energy (MME). The first database is publicly available but the second is only available through request. The Brazilian School Census is an annual survey published by the National Institute of Educational Studies and Researches Anísio Teixeira (INEP, *Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira* in Portuguese), tied to the Ministry of Education. It is a national survey that covers private and public schools, from primary to secondary education, including vocational schools. The School Census gathers data on educational establishments, classes, students and school professionals.

The Light for All in Schools list of participants is a database covering all schools identified as having improper access to electricity or no access at all by the Ministry of Education. The Ministry of Education geolocalized theses schools and informed the Ministry of Mines and Energy which schools to include in the "Light for All" program. The data is available by request and the access to it is guaranteed by the federal Information Access Law (n. 12.527/2011). The last version of LFAS database was updated between February/2014 and June/2015. Considering this, we used two censuses, 2013 and 2016, which gives us a two-period panel.

MEC/MME database identifies 8,534 schools included in the LFAS program. We excluded schools that cannot be localized by the MEC (1%). Moreover, we excluded 1,525 schools because they were no longer active in 2016 (18%). Our final database contains 13,826 observations and 6,913 schools. Of those, 97.8% have primary school programs, while only 1.23% have secondary school programs, which is why we focus on primary school.

Compared to the other schools in the Census, these schools represent, in average, 55% of schools reported as "without access" (Figure 2). We should also notice that the electrification rate has been rising since 2013. 12.9% per year in LFAS beneficiaries and 3.66% per year in schools outside of the program.

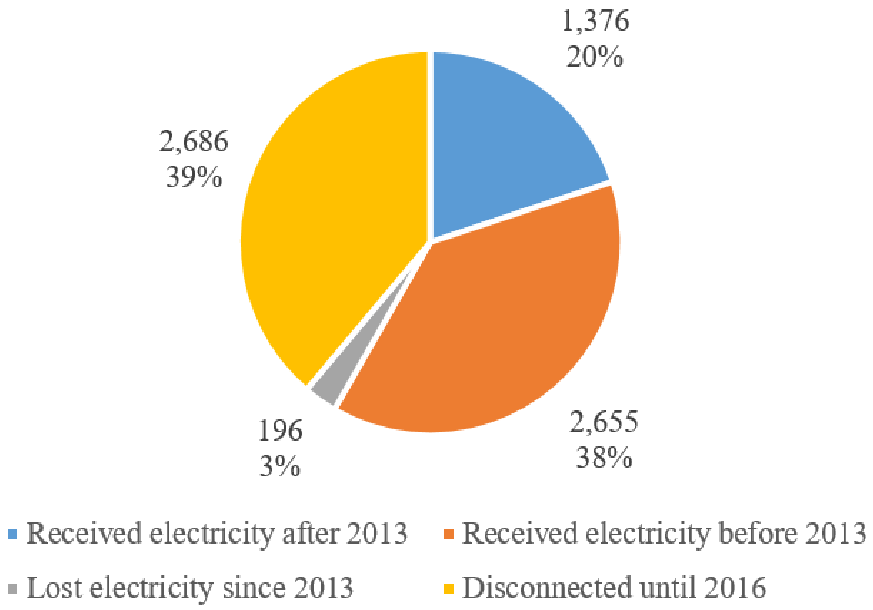
Figure 2. Percentage of schools without access to electricity



Source: Our elaboration based on data from the School Census 2013 - 2016 - Inep.

While 60% of our schools were disconnected from the grid in 2013, the share reduces to 41% in 2016. As Figure 3 shows, we classified schools by four electrification status: (i) received electricity before 2013, (ii) received electricity between 2013 and 2016, (iii) lost electricity since 2013, and (iv) disconnected from the grid until 2016. We consider to be treated by the program the schools who retain the connection to the grid up until 2016, which are the ones in blue and orange areas in Figure 3.

Figure 3. Percentage of active schools in the program by electrification status in 2016



Source: Our elaboration based on data from the School Census 2013 and 2016 - Inep.

4.2. Preliminary testing

We use a log-likelihood estimation of a multinomial logit regression model to check the electrification pattern. The multinomial logit is a useful tool to estimate the response of unordered categorical variables (Menard, 2010). The purpose of using this model is to check if the probabilities of the electrification status can be explained by the region and the characteristics of the community. The dependent variable to be estimated is the probability P of having the categorical variable Y_i in state m. Or $P(Y_i = m)$. Thus, we estimate:

$$P(Y_i = m) = \frac{\exp(Z_{mi})}{1 + \sum_{h=2}^{M} \exp(Z_{hi})}$$

Where Z_{hi} is the log-odds of each response model, following the distribution of

$$Z_{hi} = \log \frac{P(Y_i = m)}{P(Y_i = baseline)} = \alpha_h + x_i' \beta_h$$

In our model, the vector of variables x includes: (i) one dummy identifying indigenous communities, (ii) one dummy identifying *quilombola* communities, (iii) four regional dummies, identifying the Northeast, the North, the South, and the Southeast. The model omitted the *disconnected from the grid until 2016* category as the baseline, and the Central West control region.

We describe the results of this first test below (Table 2). For electrified schools (columns 3 and 4), all control variables – except for the North and Indigenous Communities in column 3 – are significant at a confidence level of 95%. This indicates that the electrification status of "has access to electricity" can be explained by a set of variables with a fitness of 0.078.

Looking at the signals, we have indigenous communities and North with negative effects on column 4 (received electricity before 2013). These variables show a positive signal between 2013 and 2016, indicating these two characteristics were treated by LFAS in a latter period.

This can explined by the fact that access to remote areas in the North region, especially to indigenous communities, is difficult. In fact, out of 515 indigenous schools, 321 (or 62%) were in the North region. In column 1, the number of rooms (positive coefficient) and the dummy for indigenous settlements (positive coefficient) are the only significant coefficients. This category, schools that lost electricity since 2013, represents only 3% of all schools, and we consider it to an exception.

Table 2. Multinomial logit electrification pattern testing

Variables	Lost energy since 2013	Disconnected until 2016	Received electricity after 2013	Received electricity before 2013
	1	2	3	4
Number of rooms	0.224***		0.403***	0.607***
	(0.0676)		(0.0314)	(0.0289)
Indigenous community	-0.0877		0.0295	-0.426***
	(0.279)		(0.125)	(0.126)
Quilombola community	1.358***		0.860***	0.597***
	(0.324)		(0.196)	(0.184)
Northeast	0.0165	Omitted	0.729**	0.905***
	(0.637)		(0.285)	(0.247)
North	0.290		0.144	-0.441*
	(0.623)		(0.280)	(0.244)
South	-10.97		2.035**	2.313***
	(744.8)		(0.883)	(0.812)
Southeast	0.550		1.062**	1.484***
	(0.972)		(0.431)	(0.372)
Constant	-3.221***		-1.748***	-1.345***
	(0.645)		(0.291)	(0.255)
Observations	6,780	6,780	6,780	6,780
LR chi2(21)	1226.16			
Prob > chi2	0			
Pseudo R2	0.0783			
Log likelihood	-7221.7351			

Source: Our elaboration based on data from the School Census 2013 and 2016 - Inep.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3. Model

From this first result, we elaborate our research question: *does electricity access have positive effects on the dropout rate of schools?* We use a differences-in-differences approach (DD) to compare treated and untreated schools between 2013 and 2016. This method allows us to isolate the effects of policy on the dropout rate evolution. The Differences-in-Differences is a useful technique to compare the effect over time of two groups, one that was treated by the policy and the control group. Angrist and Pischke (2008) define it as

$$Y_{st} = \alpha + \gamma \mathrm{Tr}_s + \lambda \mathrm{d_t} + \beta(\mathrm{Tr}_s . \mathrm{d_t}) + \epsilon_{st}$$

Where Tr is the treatment dummy, access to electricity, and d_t is the time dummy indicating if the observation is in 2016 (= 1) or in 2013 (= 0). The interaction term indicates whether the treatment was before or after the intervention. In our case, Y_{st} is the dropout rate in the first five years of primary education, by school (s) in period t. Control dummies are added to support the estimation with the region and type of community of each school.

5. Descriptive analysis

The descriptive statistics are shown on Table 3. While the mean dropout among all rural schools was 2% in 2016, that figure goes up to 3.9% in our sample[10]. Of our sample, 8% of schools are located in an indigenous community and 4% in a *quilombola* community. While 41% of our schools had energy access in 2013, that figure goes up to 58% in 2016.

Table 3: Descriptive statistics

Variables	Observations	Average	Std. Dev.	Min	Max
Year	13,826	-	-	2013	2016
Electricity access	13,826	0.49	0.50	0	1
Dropout rate in first years of primary education	13,431	4.15	8.42	0	100
Region	13,826	-	-	0	4
Indigenous community	13,826	0.07	0.26	0	1
Quilombola community	13,826	0.03	0.18	0	1

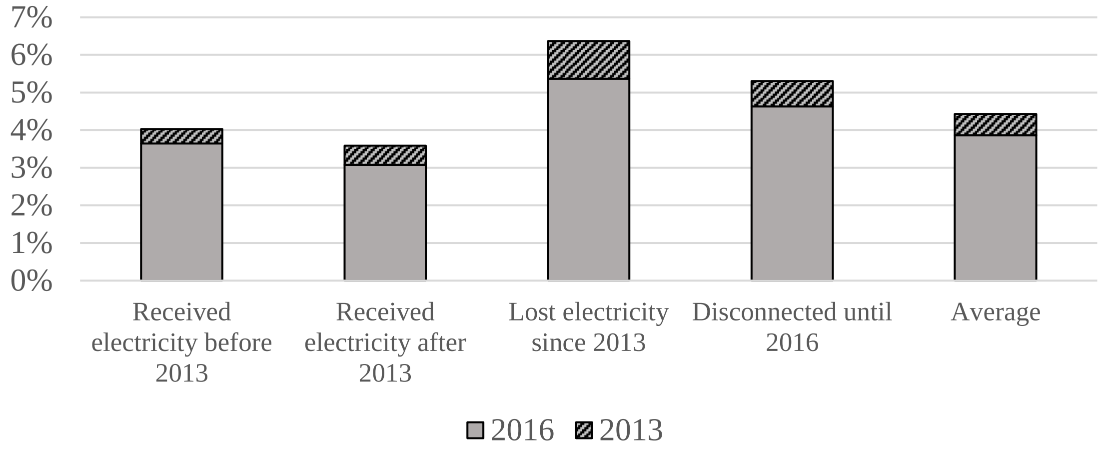
Source: Our elaboration based on data from the School Census 2013 and 2016 - Inep.

Figure 4 shows the dropout rate by the status of electrification. Overall, dropout rate dropped in all categories. Schools that never had energy had a higher rate compared to those which received electricity before 2016. Schools that lost access to electricity between 2013 and 2016 have the highest dropout rate, although this experience is rare and might be overestimated due to the number of observations.

Schools that gained access to electricity between 2013 and 2016 have the lowest average dropout rate in 2016. The decline in the dropout rate between 2013 and 2016 is steeper among schools who received electricity between 2013 and 2016 (0.51 p.p.) than among schools which received electricity before 2013 (0.38 p.p.). This could indicate that the benefits of electrification have an almost immediate impact on schools, which is diluted over time. At average, and without including any controls, schools that received access to electricity performs 0.54 p.p. or 12.28% better on reducing the dropout rate.

[10] National Institute of Educational Studies and Researches Anísio Teixeira (Inep). Indicadores educacionais. Retrieved 23 October 2018 from http://portal.inep.gov.br/web/guest/indicadores-educacionais.

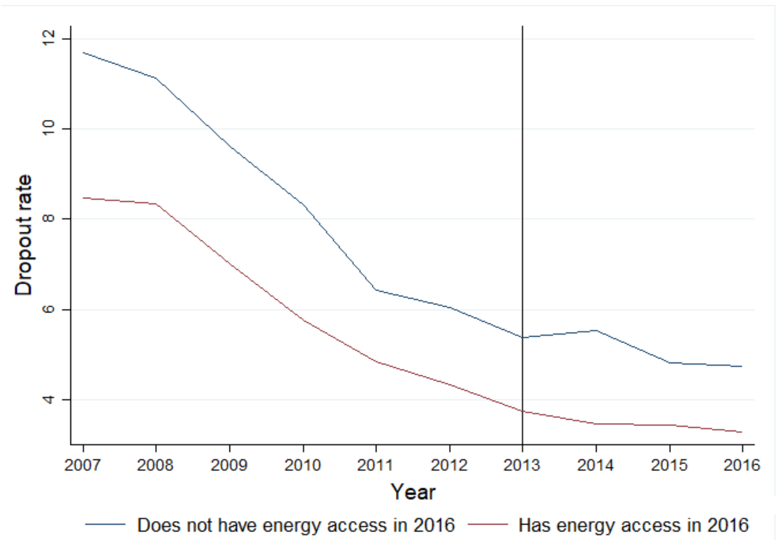
Figure 4. Mean dropout rate by electrification status, 2013 – 2016



Source: Our elaboration based on data from the School Census 2013 and 2016 - Inep.

Figure 5 shows the dropout rate trend over 10 years by electrification status in 2016. Except for the steeper descent between 2010 e 2011 for schools without energy access in 2016, the two groups have similar trends before 2013.

Figure 5: Dropout rate trend over the years, 2007 – 2016



Source: Our elaboration based on data from the School Census 2007 - 2016 - Inep.

Even when compared to other rural schools in Brazil, the LFAS present a unique profile (Table 4). We can see these are very small schools, with a 1.97 average number of employees 5.42 number of rooms. The schools in our sample have little access to ICT. Even if 58% of our schools have energy access, only 0.15% of them have computers. Regarding infrastructure, almost the totally of our schools have a precarious sewage system, only 0.66% of them have drinkable water and 0.84% of them dispose of their garbage through burning. Very few of them have either a library or teachers' accommodation.

Table 4: Schools characteristics (means test) – 2016

Variables	Our sample	Other rural schools	Differences
Classes in a school building	0.83	0.94	34.65***
Number of employees	1.97	3.65	37.08***
Number of rooms	5.42	13.05	18.92***
TV set	0.19	0.63	72.57***
DVD	0.17	0.59	67.40***
Copy machine	0.06	0.23	32.35***
Overhead projector	0.02	0.11	24.53***
Printer	0.13	0.46	54.52***
Computer	0.15	0.57	69.18***
Internet	0.04	0.33	50.65***
Drinkable water	0.66	0.79	23.65***
Water provenient from river	0.29	0.12	-38.12***
Precarious sewage system (nonexistent or septic tank)	0.99	0.46	-89.54***
Periodic garbage collection	0.03	0.34	53.44***
Garbage disposal method: Burning	0.84	0.61	-37.76***
Bathroom inside building	0.38	0.77	72.54***
Principal’s office	0.12	0.36	39.51***
Teacher’s room	0.08	0.26	33.48***
Teachers' accommodation	0.03	0.02	-3.26**
Computer lab	0.04	0.25	40.50***
Sports court	0.03	0.14	25.34***
Kitchen	0.77	0.92	38.88***
Library	0.04	0.16	26.85***
School provides food	1.00	1.00	-5.27***
Observations	6,906	116,363	123,269

Source: Our elaboration based on data from the School Census 2016 - Inep.

6. Results

Table 5 shows the results of the differences-in-differences model. The three coefficients, time, treatment and interaction are significant (at 95% of confidence level for treatment and Interaction and at 90% of confidence level for time). The time coefficient is negative, as expected by the descriptive analysis, which means the dropout rate reduces over time.

The dropout rate also reduces with energy access, as shown by the negative coefficient in variable the treatment. The interaction has a positive coefficient. This might mean the effect occurs in the short term, acting as a decelerating component of the effect. This would mean the treatment has a higher effect on children who have undergone the change in energy access than on those who later enroll in the school.

The fitness of the model is indeed still very low with R-square around 0.39, but F-test indicates that the model is overall significant. This means that omitted variables may be influencing the dropout rate in school, as expected. These variables include, but are not limited to, performance, infrastructure, child labor, lack of public transportation to access school, parental background, etc.[11]

Table 5: DD Estimation

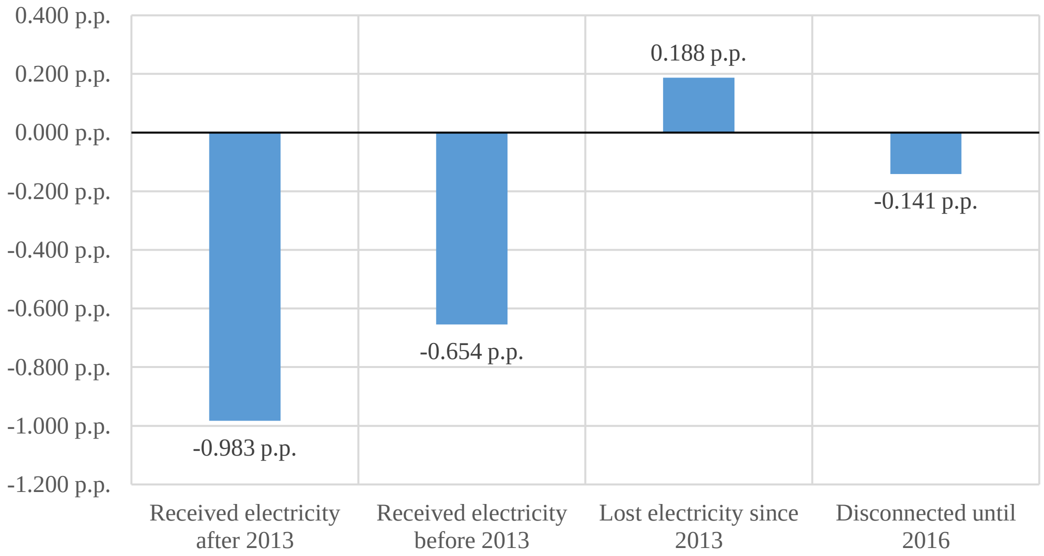
Dropout rate in initial years of primary education	Coefficient
Time (2013 = 0)	-0.0284*
	(0.0171)
Treatment (Electricity = 1)	-0.0320**
	(0.0150)
DD Time#Treatment	0.0444**
	(0.0220)
Observations	13,404
F(27, 13376)	20.2
Prob > F	0
R-square	0.0392
Adj. R-square	0.0372

Source: Our elaboration based on data from the School Census 2013 and 2016 - Inep
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: Includes control variables and their interactions (with treatment and time) for regions type of community (indigenous or *quilombola*).

Using control variable averages, we can decompose the effect of program treatment the electrification status we proposed above (Figure 6). In average, schools with access to electricity in 2016 performed much better in reducing dropout rates. Schools that received electricity between 2013 and 2016 had an average estimated decreasing of around 1 percentage point (**or 27% of improvement**) in the dropout rate, and schools that received electricity before 2013 had a reduction of -0.6 percentage point (**or 16% of improvement**) due to electrification. Conversely, the effect on untreated schools was between 0.19 p.p. and -0.14 p.p. (+3% and -3%, respectively). This effect, as expected, is very near to zero.

[11] A second estimation was done including the number of rooms in school as a proxy of the size of school. The coefficient for this variable is significant but very small (0.0004 p.p. / room) and the average effect is 0.0008 p.p., the result is neglectable, meaning that the size of school is not important in determining the dropout rate in LFAS beneficiaries. All other results are maintained.

Figure 6. Marginal effects of electrification on dropout rate by status



Source: Our elaboration based on data from the School Census 2013 and 2016 - Inep.

7. Conclusions

The aim of this study was to evaluate the impact of the program Light for All in Schools on the dropout rate in initial years of primary education. Although the benefits of electrification on learning can be huge, the effect of them on educational outcomes needs deeper research, especially in isolated and less developed regions.

We estimated the impact of the program on the dropout rate of schools using a two-year panel of schools and differences-in-differences approach. Our results show that the effects of electrification programs on the dropout rate are significant. Schools that received electricity by the program before 2013 had an improvement of 16% in the dropout rate in 3 years and schools that were treated by the program between 2013 and 2016 had an improvement of 27% in 3 years. Comparably, schools that did not receive it had a near-to-zero effect on the dropout rate due to the lack of electricity.

In general, we conclude that the Light for All in Schools was a successful program in reducing the dropout rate in vulnerable rural schools. In absolute terms, the benefit affected only 2% of the schools in Brazil (6% of rural schools) – where electricity access reaches 99.3% - but it is a huge contribution to the last mile problem. This result encourages similar programs to be adopted in other regions with similar problems of aisled communities.

These vulnerable rural communities are plagued by problems such as higher levels of poverty, worse school infrastructure and child labor. Providing electrification to their schools is an import way of improving access to quality education and ensuring the conclusion of (at least) basic education. Increasing human capital might be a start in helping these children to break away from the cycle of intergenerational poverty.

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