Impact of Regulation on the Quality of Electric Power Distribution Services in Latin America and the Caribbean

Energy Division

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Abstract

This study discusses the impact of regulation on improving the quality of electricity supply in LAC countries. For this purpose, an econometric model is applied using public data available from regulators and electricity companies of each country to analyze the impact of quality regulation measures on the average duration of interruptions per customer/year (SAIDI), the average frequency of interruptions per customer/year (SAIFI), and equivalent indicators, in addition to the influence of other companies' characteristics. We show that between 2000 and 2019, improvements in the continuity of electricity supply were observed for the nine countries studied: Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Panama, and Peru. During this same period, several countries adopted regulatory instruments to measure quality indicators and establish minimum standards or incentives to reduce interruptions in the electricity supply, contributing to the decrease of SAIDI and SAIFI. In particular, our results show the effectiveness of regulatory instruments to improve the quality of electricity services. From a sample of 143 electricity distributors, we estimate that average SAIDI has decreased by 40% and average SAIFI by 45%.

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1 Introduction

This study analyzes the impact of regulation on electricity supply quality in Latin America and the Caribbean (LAC). This issue is increasingly important, given the growing need for reliable electrical services to fuel the electrification and digitization of the economy and guarantee the continuity of economic activities.

Electricity supply quality depends on proper functioning and coordination of the entire chain: generation, transmission, and distribution. In this study, we focus on distribution companies, where the existence of "good regulation" plays an important role. Regulated companies are responsible for supplying electricity to end consumers through a low-voltage network infrastructure[1] at the end of the distribution network. Distributors are the closest part of the electric system to the final consumer. Due to economies of scale, the provision of the distribution service is generally the responsibility of a single company for each geographical area, and the service acts as a natural monopoly in each zone.

The market structure does not provide enough incentives for service quality, given the absence of intra-zone competition in distribution and the difficulty of creating a cost-effective decentralized option for most consumers.[2] In this context, concession contracts and/or regulatory frameworks are essential tools to promote better quality service.

On the other hand, the regulator has a significant challenge in achieving a balance between quality and cost-efficiency, in particular, because operational information is, in many cases, private, making it difficult for the regulator to manage this trade-off. It is difficult to acquire cost information due to firms' strategic incentives and because consumption information is scattered and can change over time. Information asymmetry tends to hamper regulations' efficacy. However, regulatory tools seek to find *proxies* for this information and allow comparison of different distributors, establishing limits and incentives to improve quality that can efficiently regulate the majority of distributors. On the other side of the information asymmetry is the regulator's lack of knowledge about service quality desired by final consumers: how much they are willing to pay for more quality and, above all, whether they are satisfied with current electricity service provision. This information also tends to be difficult to compile due to user dispersion and low interaction with them by the regulator.

Studying to what extent quality regulation will impact service improvement is an important step for policymakers in LAC since: (i) it highlights the need to implement regulation to improve quality in countries that do not yet have it; (ii) it underlines the scope as well as the limits of this regulation, allowing us to discuss next steps to advance on this issue; and (iii) it offers elements for comparison between regulators and between distribution companies.

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1 It differs from transmission, in that the latter is intended to transport greater distances and higher voltage from generation plants to distribution centers, which in general terms are cities and populated or industrial centers, where electricity voltage is reduced and distribution activity begins.

2 The advance of distributed energy is motivating changes to incentives for installers; however, adoption is still concentrated in consumer groups (Chueca et al., 2020).

Herein, we study quality regulation efficiency on electricity supply continuity (measured by SAIDI and SAIFI indicators) and the influence of other characteristics of distribution companies. Given data availability restrictions and current market structure, we study nine countries where public data is available and generally with more than one electricity distributor – Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Panama, and Peru. This study is the first to quantitatively analyze the impact of regulation on duration and frequency of electricity service interruptions measured with SAIDI and SAIFI. We do that using data for 17 years, from 2003 to 2019.

In what follows, we begin by presenting background of the problem of electricity service quality in LAC, thus underlining the importance of addressing this issue and seeking solutions. Next, we present types of regulatory instruments most commonly used to assess energy supply quality. Then, we present the data and econometric methodology. Finally, we close with results and a conclusion.

2 Background: Why is electricity supply quality in LAC important?

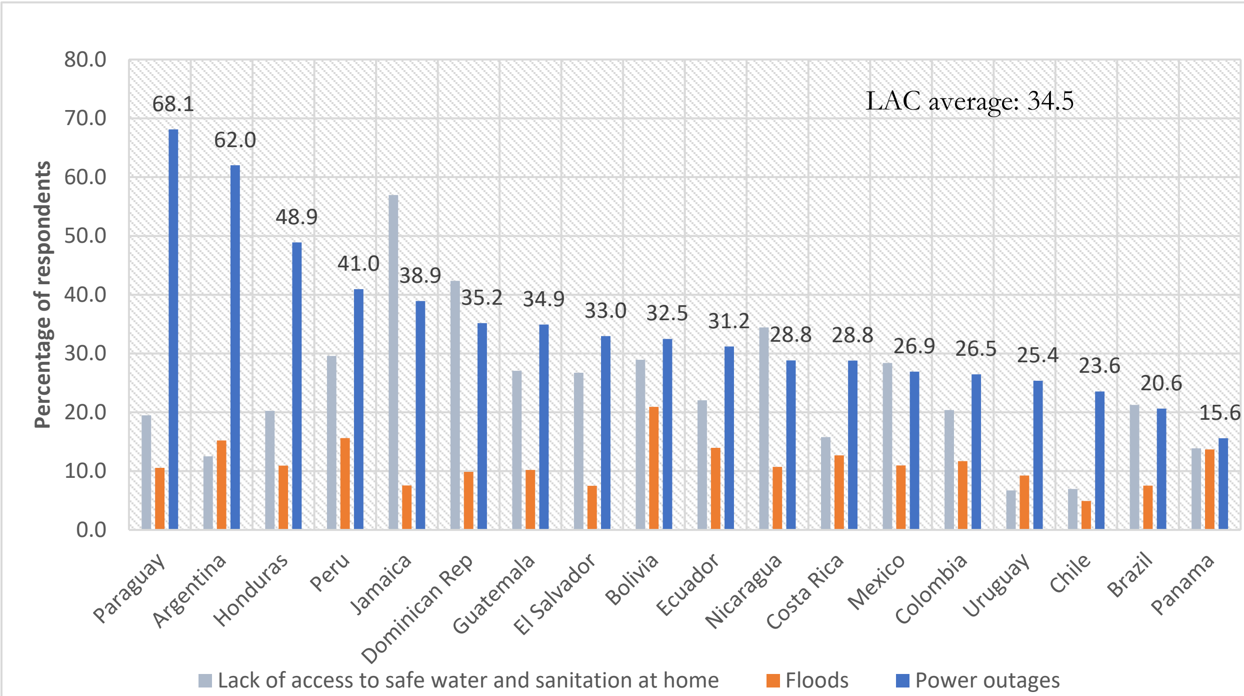
Electricity coverage has brought various benefits to the population, allowing an increase in employment rates, industrialization, and the use of new technologies in homes and businesses. Other less direct benefits can be observed in the domains of health, education, and gender equality, among other aspects (Ravillard et al., 2019). However, electricity provision in many developing countries is often rationed, limited, unstable, and/or of poor quality (Dinkelman, 2011; Rud, 2012, cited in Burlando, 2014).

LAC countries have significantly reduced the gap in electricity infrastructure access, but access alone does not guarantee that users will benefit from services derived from energy sources, which is what actually counts. For electricity connection to be truly useful, electricity service must be provided affordably and reliably (Carvajal et al., 2020). In the past two decades, LAC has experienced substantial improvement in electric service quality. However, quality improvement has been slower than improvement in other regions of the world (Cavallo et al., 2020).

2.1 Power outages are a concern for Latin American citizens

In terms of citizens' perceptions, there is significant concern about electricity supply interruptions. According to the 2018-2019 survey conducted by Latin American Public Opinion Project (LAPOP), power outages concern more than 34% of respondents. In addition, in most countries of the region, this problem is perceived as more serious than other problems associated with basic infrastructure services, such as water supply (lack of water) and sewerage (floods) (see Figure 1).

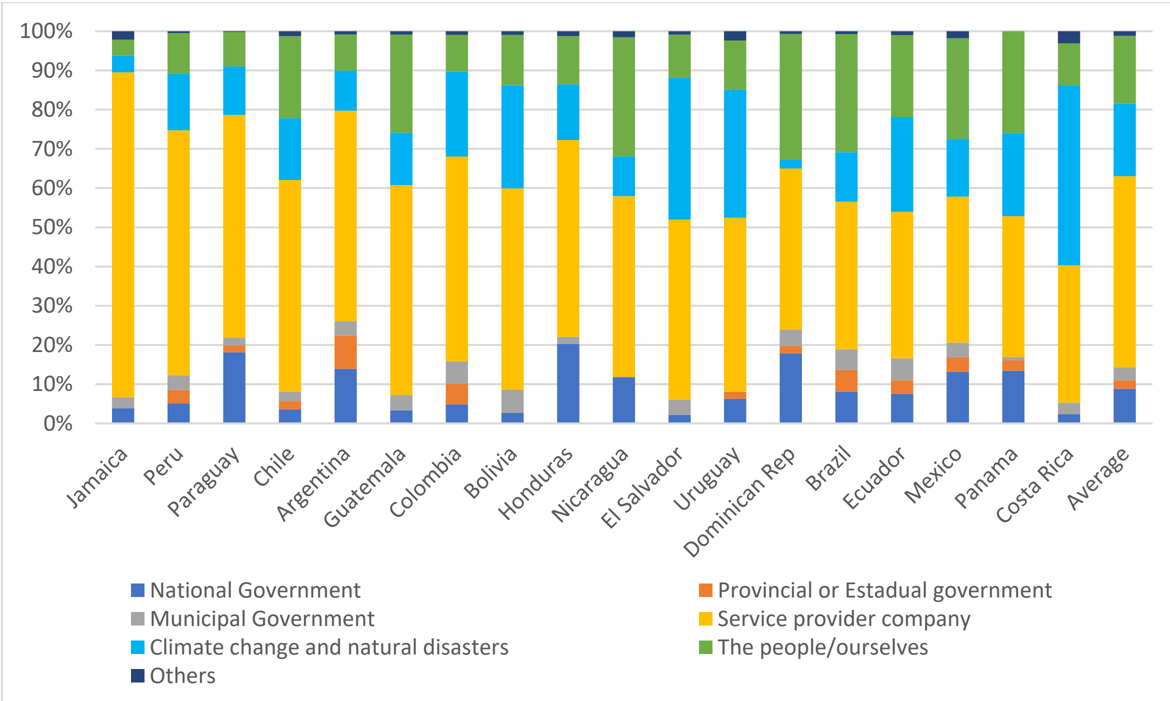
Figure 1. Basic service problems mentioned by LAC households, 2018-2019.



Source: Authors' design using LAPOP data (2018-2019)

Additionally, on average, 48.8% of respondents who were interviewed believe that electricity distributors are to blame for power interruptions in their country (Figure 2), while only 18.4% of respondents associate interruptions with natural disasters and climate change, 17.4% associate them with "people/ourselves" (accidents at home, theft, damage to infrastructure, among other variables), and 14.3% blame national, provincial, and local governments.

Figure 2. Who do you think bears primary responsibility for power outages?



Source: Authors' design using LAPOP data (2018-2019)

Low quality perceived as frequent and prolonged interruptions can constitute a barrier to economic development and competitiveness. High costs, frequent power outages, and business losses negatively affect the population's quality of life (Fay & Morrison, 2007).

2.2 Power outages impact households' quality of life and disparities

Interruptions cause discomfort in home settings, affecting food preservation, water, heat, air-conditioning, and heater use, and educational and recreational activities (mainly at night), as well as internet access and the remote work routine in the home.

Service quality problems, especially when recurrent and prolonged, force households to resort to other energy providers that may involve more expensive and polluting services, such as companies with their own generators or sellers of candles and battery lamps (Levy & Carrasco, 2020). In addition, interruptions can force families in rural areas to collect firewood, buy kerosene for heating and cooking food, and buy ice packs to keep their food in edible condition (Ravillard et al., 2020; Carvajal et al., 2020). Such problems mainly affect women and children in rural areas since they are generally responsible for seeking these alternative energy sources. Cases of violence and abuse against women and girls have even been documented because they are forced to move away from their communities in this search (Beaujon, 2020).

2.3 Supply interruption impacts companies' productivity, which is even more worrying in the context of economic digitalization

Since electricity is an essential input for the entire production system, low quality electricity service (power outages, low quantity supplied, or scarcity) can significantly impact companies' productivity, competitiveness, and income, especially for those that use energy intensively (Allcott et al., 2016; Cavallo et al., 2020). According to Levy and Carrasco (2020), service interruptions can raise costs due to production volume losses associated with the start and stop of production cycles.

In LAC, Cavallo et al. (2020) mention that companies that experience interruptions are considerably less productive and profitable than those that enjoy uninterrupted electricity consumption. According to figures presented in a report by Acevedo et al. (2019), companies in the region that experience interruptions report annual sales losses of between 0.3% and 2.5%, and these losses increase to 3.4% if those with the highest incidence are considered (10 % most affected). Since losses can be severe, companies with the capacity and resources seek alternative energy to deal with power outages by purchasing their own (off-grid) generators. Other companies, unable to generate their own power in the face of interruptions, may be forced to stop production. According to the World Bank (2021), in 2010, 22.5% of companies in Latin America had their own generator or had access to a shared generator to reduce loss risks caused by power outages.

In addition, the importance of electricity service quality for the industry has been growing in the digitalization era. Energy has played a fundamental role in the different industrial revolutions.[3] Its role continues to be relevant in the context of the Fourth Industrial Revolution, a product of the fusion of current technologies such as Big Data, artificial intelligence (A.I.), and the internet of things (IoT), all of which are generating greater efficiency in production processes (IDB & Telefónica, 2019). For this reason, it is essential to guarantee electricity service stability, so that countries of the region can participate and take advantage of the benefits of this revolution with efficiency gains while maintaining international competitiveness. All this digitalization and real-time data generation require cloud storage services and data processing centers, which in turn require a quality electrical service for their operation and good performance (Hallack et al., 2019).

Beyond the benefits for households and businesses, increase in electricity service quality should be seen as a strategic issue for Latin American countries in this new stage of technological development where digitization is a central element. The economic and social value of electrical service quality increases, and consequently, a greater demand for quality services should be expected. On the other hand, in the context of climate change, the increased frequency of extreme events is expected to increase disruption probability.

How this growing demand for quality electricity services will be transferred to regulated electricity companies will depend on regulation.

2.4 When the regulator of a monopoly defines rates, it also defines service quality incentives

Since the electricity distributors are a monopoly, there are no economic incentives to achieve an efficient level of services and prices from the economic point of view. For distributors, service quality means costs. Thus, rate regulation has to act to improve service quality. If it is not considered, a company seeking to maximize benefits would have incentives to minimize costs and thus have quality levels below the efficient one. However, optimal regulation cannot be expected either, given the asymmetry of information between distributors and regulators. The regulator has the role and the challenge of creating mechanisms that encourage an efficient increase in quality levels.

Improving electrical energy service quality implies supply costs due to the need for greater maintenance, for example. Deutschmann et al. (2021) highlight the importance of evaluating whether the willingness to pay for quality improvement is compatible with the increase in costs incurred by the electricity distribution company. In addition, it finds that households and businesses are generally willing to pay an additional premium on top of current rates if this leads to a significant improvement in quality.

From an economic efficiency perspective, according to Fumagalli et al. (2017), economic efficiency is achieved when the user's willingness to pay for an extra quality unit is equivalent to the additional cost incurred by the distribution company for that extra quality unit. Similarly, according to Mori (2021), the acceptability of implementing tariffs that reflect costs necessary to improve infrastructure services can be a challenge. Still, they can generate a lasting effect on customer satisfaction.

From the point of view of economic theory, the regulator is expected to play an important and active role in guaranteeing the quality of electricity services, even knowing that this role is not perfect. Quality regulation has become an important part of tariff regulations in LAC countries. In the next section, we will discuss how we can estimate the impact of active quality regulation measures on the indicators of electricity service interruption. And in the following section, we analyze whether the implementation of quality regulation impacts the indicator of interruptions in the countries.

3 Estimating the impact of regulatory instruments on electricity supply quality

Ajodhia et al. (2006) evaluated the effect of introducing a "rewards and sanctions" type scheme with a margin of tolerance for the case of Italy between 2000 and 2003. The authors found a positive effect on quality since both SAIDI and SAIFI national averages decreased significantly (that is, service quality improved in this period). It is important to note that although this result is interesting and goes in the expected direction, based on the theory and the characteristics of the data, the empirical evidence, in this case, must be considered carefully since it only constitutes a comparison of SAIDI and SAIFI before and after the regulatory change.

Ter-Martirosyan and Kwoka (2010) analyzed the effects of regulation for quality in SAIDI and SAIFI for the United States of America (USA). The authors took advantage of the differences in regulatory schemes applied to different electricity service companies from 1993 to 1999. Some of these firms went from being regulated based on the rate of return, to incentive regulation plans, that is, through a ceiling price or some similar variant; in addition, in some cases, the regulation by incentives was accompanied by some scheme of compliance with quality standards, with rewards, or sanctions. The authors found that this second scheme achieved improvements in quality control metrics.

This section discusses the effectiveness of regulation in improving the electricity supply quality in LAC. With this purpose in mind, we build on the study of Ter-Martirosyan and Kwoka (2010) by adapting and applying their methodology to our case study. An econometric model is applied to analyze the impact of quality regulation on SAIDI and SAIFI. The influence of other characteristics of distribution companies is included in the analysis. Countries studied include **Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Panama, and Peru**. The selection of these countries was mainly related to the availability of public information. In addition, most of these countries have a regulator that implements quality regulation, and each country has more than one distribution company. In addition, since the countries do not separate distribution and commercialization of electrical energy, we could directly analyze the *performance data* of the distribution companies. In the next section, we explain the source and capture of data for each country evaluated, and in the following section, we turn to the methodology of the econometric model.

3.1 Data on service quality for distribution companies

In this work, we focus on the third approach (SAIDI, SAIFI) because these indicators are more easily comparable between countries. The best known and most used international standard is "IEEE Std 1366-1998 Guide for electric power distribution reliability indices," updated in 2012. According to IEEE (2012), SAIDI is defined as the total number of minutes of service interruptions in a year, divided by the number of customers served; meanwhile, SAIFI measures how often a customer's service is interrupted on average in a given year. It is important to note that some countries have small methodological differences when counting their electricity supply continuity indicators. Some countries only consider interruptions lasting more than three minutes; others only consider interruptions lasting more than five minutes. There are also some differences in the weighting of national indices: some by customers, others by connection point or feeder.

Table 1 shows the universe of companies studied and the number of companies per country with information found for the SAIDI and SAIFI quality indicators for at least two years. Of 160 companies surveyed, 143 were selected due to data availability. Countries with at least two electricity distributors and a single regulator were chosen for the analysis. The selected countries and their respective number of companies are listed in Table 1.

Table 1. Companies with available information on quality.

Countries	Companies	Companies with SAIDI Information	Companies with SAIFI Information
1 Brazil	63	63	63
2 Chile	18	1	1
3 Colombia	21	21	21
4 Costa Rica	8	8	8
5 Dominican Republic	4	4	4
6 Ecuador	22	22	22
7 El Salvador	6	6	6
8 Panama	3	3	3
9 Peru	15	15	15
Total	**160**	**143**	**143**

Source: Authors' design

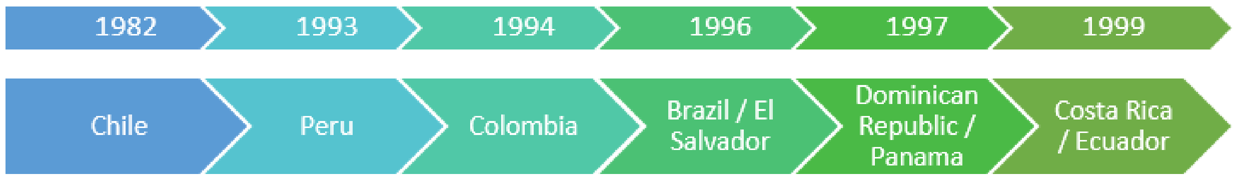
Herein we use the SAIDI and SAIFI indicators for different distributors as dependent variables of our econometric model. In addition, the model uses data on the quality regulation implemented in each country and the companies' characteristics, such as number of clients and the capital structure: public and private. While public companies' capital is controlled by the government, private companies do not have the government as majority shareholder.

3.2 Quality regulation variables

The regulation of quality in the distribution section must consider different aspects. For Fumagalli et al. (2007), power quality can be viewed from three angles: (i) commercial quality, where aspects directly related to the distributor's relationship with the customer are considered (such as installation time for a new connection, precision in the measurement of consumption and billing, assistance with complaints, etc.); (ii) voltage quality, which refers to variations in the characteristics of voltage concerning standard values; and (iii) supply continuity, which relates to energy supply interruptions that are described by the number of interruptions and their duration. This chapter presents the regulatory instruments related to the continuity of the electric power supply for the nine selected countries since we focus on SAIDI and SAIFI as quality measures.

The existence of regulation of the energy distribution service is based on the sector's characteristics, which depend on how the electricity sector has been liberalized. Electricity sector liberalization in LAC took place progressively. It started in Chile in 1982 (Figure 3). Of the nine countries analyzed, Peru was the second country to liberalize its electricity sector in 1993, followed in 1994 by liberalization in Colombia and then in 1996 in Brazil and El Salvador. A year later, in 1997, the Dominican Republic and Panama liberalized their electricity sectors. Finally, Costa Rica and Ecuador joined[4] in 1999.

Figure 3. Liberalization of the electricity sector in Latin American and Caribbean countries



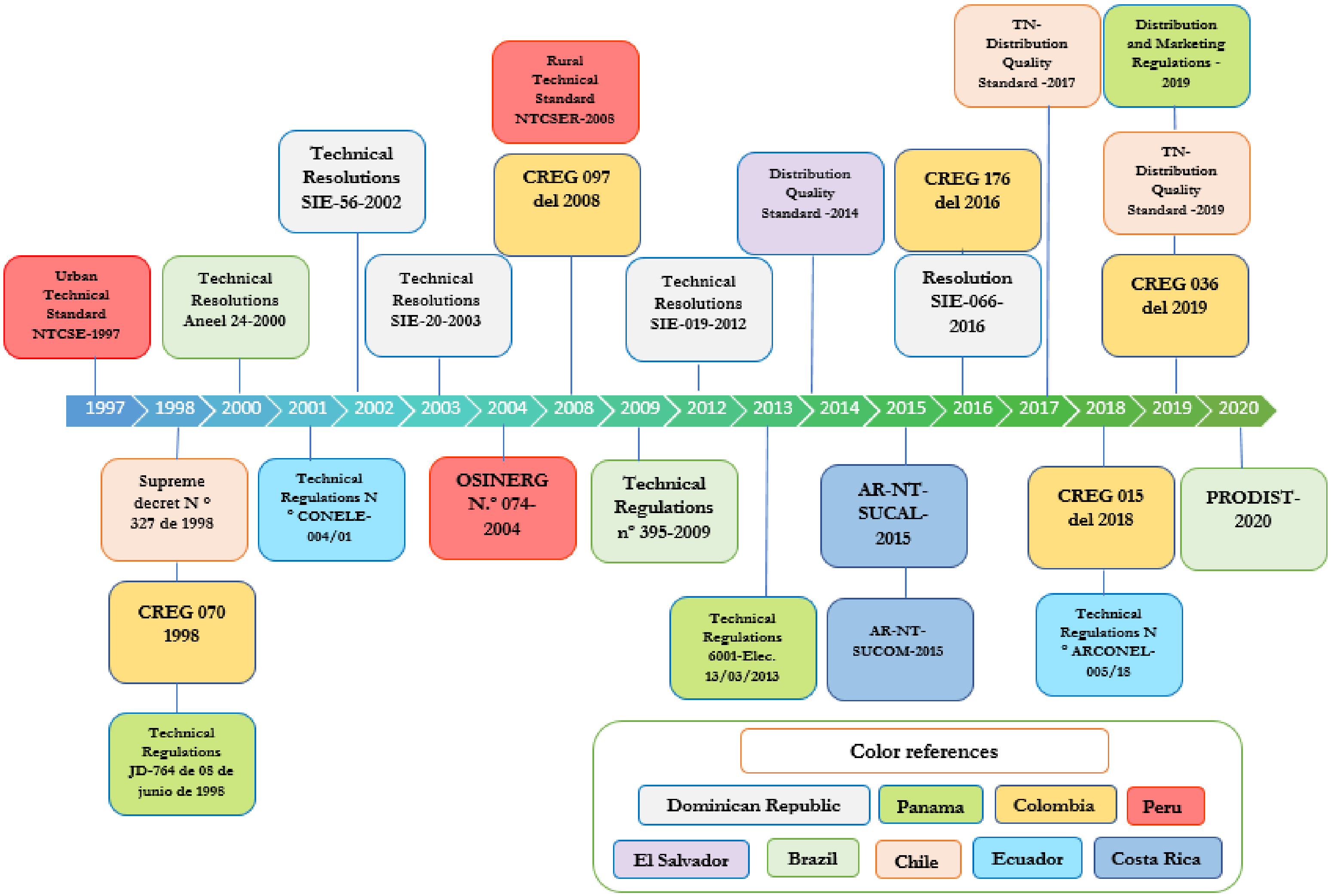
Source: Authors' design

As Levy and Carrasco (2020) highlight, the liberalization process in these countries opened the market to private investment. In this process, legal and regulatory frameworks were developed with different components, such as: (i) operation of transmission and distribution delivered to concession and in a regulated manner; (ii) obligation of the concessionary distributors to supply their concession area; (iii) economic signals that require compensating customers to stimulate service quality in some of the countries.

Regarding the quality of electricity distribution, we show in Figure 4 that the regulations aimed at ensuring reliability and good quality in energy distribution appear from the second half of the 1990s and were modified or supplemented by new regulations in subsequent years. In this regard, Table 2 provides more details on the types of regulatory instruments adopted by countries included in this study.

4 However, the Ecuadorian electricity distribution market has not been competitive since 2015. The Organic Law of the Public Service of Electric Power (LOSPEE) establishes in articles 43 and 49 that the purchase and sale of electric power that is carried out between participants of the electric power sector through contracts, as well as short-term transactions, will be settled by the National State Electricity Operator-CENACE.

Figure 4. Timeline of quality regulation in LAC countries



Source: Authors' design based on countries' regulations

In addition, it is important to highlight that the countries have progressively adopted the SAIDI and SAIFI international indicators. Adoption in Peru occurred in 2004 through OSINERG document No. 074-2004-OS/CD. In the Dominican Republic, it was in 2002 through Resolution SIE-56-2002. In Brazil and Costa Rica, the indicators equivalent to SAIDI and SAIFI that are currently used, were implemented after the national resolutions of 2009 and 2015, respectively. Finally, Colombia adopted SAIDI and SAIFI indicators in 2016, before equivalent indicators were used.

Looking at the history of regulations and the implementation of continuity indicators compatible with international quality standards, we have defined the year of the most important recent regulations in terms of service quality. These were the regulations that we used in our econometric model. The results of this analysis, along with the years in which the most recent and significant regulatory instruments were implemented, are presented in Table 2.

Table 2. Most important regulation to improve electricity service quality

Countries	Technical regulations and standards	Implemented Regulatory Instruments
Brazil	ANEEL Resolution 395/2009	Adoption of indicators equivalent to SAIDI and SAIFI, and Limits with Financial Compensation (Penalty)
Chile	Technical Standard 2019	Adoption of SAIDI and SAIFI indicators, limits Fines
Colombia	Service Quality CREG 097/2008	Adoption of indicators equivalent to SAIDI and SAIFI, incentives with indifference bands, compensation for "worst served" users and extra quality contracts
Costa Rica	AR NT SUCAL y SUCOM 2015	Adoption of indicators equivalent to SAIDI and SAIFI, Limits and Compensations
Dominican Republic	SIE 19/2012	Change of the measurement process and beginning of the transition process for the adoption of SAIDI and SAIFI, limits and compensations
Ecuador	Technical Regulation No. ARCONEL 005/2018. (Updated)	Adoption of indicators equivalent to SAIDI and SAIFI, Limits, compensation and sanctions by type of non-compliance.
El Salvador	Quality Standard-2014	Adoption of indicators equivalent to SAIDI and SAIFI, and Compensations
Panama	Technical Resolution AN 6001-2013	Adoption of indicators equivalent to SAIDI and SAIFI Compensations and penalties
Perú	OSINERG 074/2004	Adoption of indicators equivalent to SAIDI and SAIFI, and Compensations

Source: Authors' design, based on countries' regulations

To study the impact of these regulations, we analyzed the average SAIDI and SAIFI before and after the regulation was implemented. The only exception is Panama, due to a lack of measure before the regulation went into effect. Table 3 shows the companies' average SAIDI and SAIFI data with available information by country.[5] When we look at the indicators by company before and after regulation, we see that the two indicators turned out to be smaller after implementing

[5] The evolution of SAIDI and SAIFI indicators for each of the 143 companies is presented in Annex 1.

quality regulation in the analyzed countries: the average SAIDI of companies goes from 40.8 to 24.1, while the average SAIFI goes from 29.7 to 16.2.

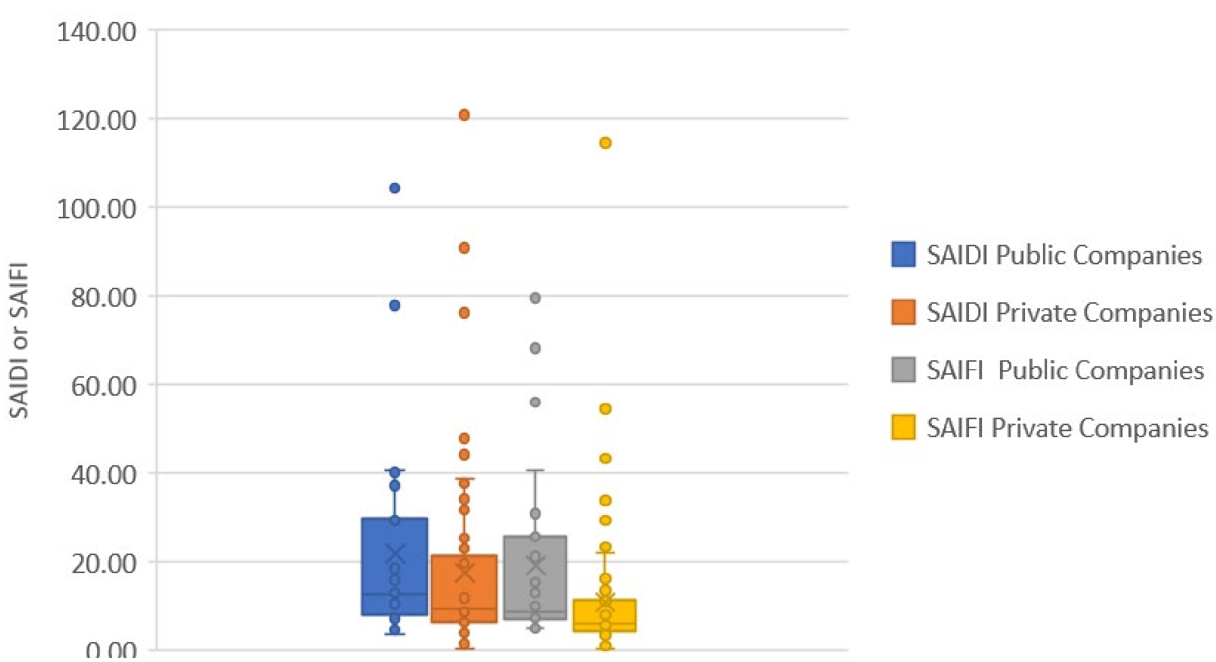
Table 3. Quality before and after implementation of the regulation

Sample of companies per country	Year of Regulation	SAIDI or equivalent		SAIFI or equivalent	
		Before Regulation	After Regulation	Before Regulation	After Regulation
Brazil	2009	17.6	16.8	16.2	12
Chile	2019	3.6	n.a.	9.1	n.a.
Colombia	2008	130	32.9	83.7	33.6
Costa Rica	2015	9.7	10	11.1	7.8
Dominican Republic	2012	128.5	115.7	40	26.8
Ecuador	2018	104.4	14.1	82.5	9.3
El Salvador	2014	21	8.4	9.9	3.5
Panama	2013	22.8	43.6	10.3	18.5
Peru	2004	n.a.	32	n.a.	15
Total Sample of Companies		**40.8**	**24.1**	**29.7**	**16.2**

Source: Authors' design

We also consider the importance of ownership for quality results. On the one hand, we observe (Figure 5) that public companies tend to have higher average SAIDI and SAIFI. On the other hand, the dispersion of these indicators is greater in private companies. Indeed, the worst performers overall are private.

Figure 5. SAIDI and SAIFI for public and private companies, 2018



Source: Authors' design

3.3 The impact of regulation on electricity service quality in LAC

We apply an econometric model to a balanced panel using SAIDI and SAIFI as dependent variables. Our methodology is inspired by the work of Ter-Martirosyan and Kwoka (2010) for the United States. The explanatory variable "$Regulation$" is a dummy variable that summarizes "whether or not there is a key regulation on the quality of electricity supply that year." In addition, we use a vector with control variables that include other variables with information about the distribution companies.

Equation (1) is regressed on the Quality variable, alternatively identified as SAIDI or SAIFI, to obtain the n estimators $corresponding$ to all the control variables, where ***i*** stands for the firm and ***t*** for the year.

$$Quality_{i,t} = \beta_0 + \beta_1 * Regulation_{it} + \beta_2 * PubliRegulator_{it} + \beta_3 * Public_{it} + \mathrm{e}_{it} \quad (1)$$

In particular, for firm ***i*** in year ***t***, β_1 is the impact coefficient of the variable of greatest interest "presence of regulation for electricity quality" ($Regulation_{i,t}$), β_2 the impact coefficient of the control variable "presence of transparent publication of the companies' SAIDI or SAIFI data on the regulator's website" ($PubliRegulator_{it}$), β_3 the impact coefficient for the control variable that reports whether the company is public ($Public_{it}$) ;[6] and finally u_i and e_{it} are residuals. Table 4 details the model's variables. Finally, we include annual fixed effects to control the trend of electricity supply quality in each firm, ***i*** .

We assume that there is endogeneity between the dependent variables (alternatively SAIDI or SAIFI) and the variable $Regulation_{i,t}$ for two reasons. First, we cannot exclude that implementing regulations may result from poor power supply quality levels, and in this case, we can speak of reverse causality. Second, it is likely that improvements in electricity quality regulation are due to administrative changes in regulatory authorities that simultaneously influence service quality and the implementation of regulatory innovations. In this case, we may be in the presence of an omitted variable problem.

[6] We also tried to include an interaction between the regulation variable and whether the company is public or private, but the results were not conclusive. This can be explained by the sample containing only information on companies from countries that have more than one distribution company and only one regulator. Therefore, in the same country, the same regulation intervenes both on public companies and private companies. The results for those alternative specifications can be made available by the authors upon request.

Table 4. Variables in the Econometric Model

Name	Description	Type	Unit	Interval	Hypothesis with relation to the sign of the coefficient
$Quality_{i,t}$	In estimation 1, SAIDI for the company (i) in the year (t); in the estimation2, SAIFI for the company (i) in the year (t);	Dependent	In estimation 1, average interruption duration per customer per year; in model 2, number of interruptions per customer per year	[0; ∞+]	-
$Regulation_{it}$	If there is no heat regulation this year.	Independent/ Variable of interest	dummy	0 o 1	Negative
$PubliRegulator_{it}$	It informs if there is no published information on the company's performance (i) in the regulator's site in a transparent, systematic and accessible way (t). It takes the value 1 if available; otherwise the value will be zero.	Independent/ Control	dummy	0 o 1	Negative
$Public_{it}$	It informs if the company is public or not, it takes the value of 1 in the year (t) if the company (i) is public; and 0 otherwise.	Independent/ Control	dummy	0 o 1	Zero or Positive
UC_{it}	Number of clients of the company (i) in the year (t);	Instrumental	clients	[0; ∞+]	Negative

Source: Authors' design

To get around these obstacles, we use (IV) the Number of Clients as an instrumental variable, a proxy for company size. We ran several tests to confirm this choice. First, we ran an endogeneity test to measure relevance of the chosen variables on our model, and another test to identify whether the selected instruments were weak. That could be the case if the variables are overidentified in their explanatory contribution to the model.[7] We reject the null hypothesis that the variables are exogenous and that the instruments are weak[8], thereby validating our estimation methodology.

[7] These tests correspond to the "robust test score" and "robust regression-based test" of Wooldridge (1995), along with the report of various statistics that measure the relevance of excluded exogenous variables, which are run after estimating " two-stage least squares" with instrumental variables.
[8] The results of these tests can be made available by the authors upon request.

Likewise, the omitted variable test[9] showed that the two models lacked one or more variables. For this reason, we chose to include random effects. The justification for selecting random effects over fixed effects is based on several reasons. First, when running the Hausman test, we saw that the difference between the coefficients of the variables was not systematic. Second, for most utilities, significant changes in power quality regulation are punctual and occur only in a given year. The use of fixed effects, in this case, would result in substantial collinearity with the dummy variable linked to the existence of regulation. It would make it very difficult to identify the impact of regulation separately.[10] After performing the random effect estimation, results are the same as the standard OLS regression results with IV. That can be due to several phenomena. Either the variance of unobserved effects is negative, which would imply that it would be automatically replaced by zero, or there is a negative serial correlation between the residuals. First, and to eliminate this last hypothesis, we estimate the regression again with random effects, including robust standard errors, which gives us the same results. To eliminate the possibility that the variance of the unobserved effects is equal to zero, we ran the Breusch and Pagan Lagrangian multiplier test for random effects.[11] The results validate the final specification we use in the next section.

4 Evidence of regulation's effects on electricity supply quality: Presentation and discussion of results

This section first presents a brief description of the evolution of the average duration of interruptions per customer, per year (SAIDI), and the frequency of interruptions per customer, per year (SAIFI) over the last 20 years.

Table 5 presents the results of the estimations with SAIDI as the dependent variable and Table 6 with SAIFI as the dependent variable. The variable of interest (Regulation) is significant, with a confidence level greater than 99% in all estimates (except when including firm fixed effects), and robust in explaining both SAIDI and SAIFI. Furthermore, despite the different controls, effects, and variables, the sign of the coefficient of the Regulation variable remains negative and significant in five of the six specifications. Confirming our hypothesis, the negative sign of the variable of interest indicates that **the regulation was effective and led to improvement in**

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[9] More specifically, we ran the Ramsey RESET ("regression specification-error test") for omitted variables. RESET tests whether omitted variables are not causing misspecification ("misspecification") in the model. The null hypothesis is that there are no omitted variables, which was rejected at 5%.

[10] In addition to the variables presented in Table 4 , we tried adding other variables in the estimates, such as publication of quality indicators only on the companies' website, the presence of different types of regulatory instruments related to the quality of the energy supply electricity (limits, continuous incentives, and extra quality contracts), companies' operating costs (OPEX), the length of the distribution network and the relationship between the number of customers and the length (the density of customers per km of network of distribution). The variables regarding different types of regulatory instruments presented a strong correlation with the instrumental variable, and the OPEX variable was eliminated from the model because it presented a high correlation with the variables number of clients (UC_{it}). In the case of the length and density of the network, these variables were removed from the model due to their small number of observations. Lastly, the use of the extra quality contracts regulatory instrument cannot be used, because it is available only for Colombia.

[11] This is run on the results of the regression with the random effects. We reject the null hypothesis that the variance of the unobserved fixed effects is equal to zero at 5%, and are then left with the fact that there are random effects. The results of these tests are available from the authors upon request.

electricity service continuity, both in terms of a decrease in duration and a decrease in average frequency of interruptions per customer.

We also consider the control variables *PublicationRegulator* (which indicates the publication of companies' SAIDI or SAIFI data on the regulator's website); and *Public* (which informs whether the company is public). The *PublicationRegulator* variable is only significant to explain SAIDI and SAIFI in the specification that only considers year effects (column 3 in Table 5 and Table 6). Instead, the *Public* variable is significant at the 99% confidence level to explain both SAIDI and SAIFI in three of the four estimates, being omitted only in the one in which company fixed effects are considered. That the *Public* variable is positive and significant indicates that, on average, public companies tend to perform worse in terms of quality indicators. This result must be taken with care, given the descriptive statistics we presented in Figure 5.

The year variables are statistically significant at a confidence level of 99% since 2010 because Brazil - the country with the largest number of companies in the sample - began regulating in 2010. The significant coefficients are positive and tend to decrease over time. In other words, the year variable indicates that SAIDI and SAIFI indicators tend to decrease over time, which indicates an increase in quality over time. Regarding the effects, we see that random effects (column 6) are equal to results of the standard OLS regression with instrumental variable (column 4), reinforcing the estimates' robustness.

Finally, it is important to highlight that the results of the estimations analyzing SAIDI and SAIFI averages before and after regulation show that SAIDI and SAIFI turned out to be smaller after quality regulation implementation.

Table 5. Results with SAIDI as the Dependent Variable

VARIABLES (DV: SAIDI)	(1) OLS	(2) OLS	(3) OLS	(4) 2SLS IV	(5) FE	(6) RE
Regulation	-18.59***	-46.24***	-39.61***	-89.09***	710.1	-86.38***
	(2,667)	(3,636)	(3,646)	(17.67)	(767.7)	(21.13)
PublicationRegulator			-6,547*	0.369	-39.28	4,221
			(3,481)	(5,207)	(70.12)	(5,704)
Public			30.29***	17.16***		21.43***
			(3,137)	(5,750)		(7,166)
2004.year		6,374	4,131	0.357	-41.57	2,507
		(8,593)	(8,311)	(9,565)	(51.73)	(9,017)
2005.year		8,011	5,269	2,646	-38.98	4,592
		(8,566)	(8,286)	(9,532)	(51.06)	(8,987)
2006.year		8,011	4,775	3,680	-54.03	5,910
		(8,514)	(8,239)	(9,443)	(65.56)	(8,932)
2007.year		9,737	6,575	5,689	-52.02	7,919
		(8,489)	(8,214)	(9,443)	(65.56)	(8,932)
2008.year		9,812	6,633	7,132	-53.95	8,425
		(8,440)	(8,168)	(9,306)	(65.99)	(8,821)
2009.year		12.99	9,926	12.20	-68.31	13.39
		(8,420)	(8,149)	(9,335)	(83.47)	(8,897)
2010.year		45.99***	37.17***	82.56***	-644.3	81.30***
		(8,785)	(8,531)	(17.57)	(700.2)	(20.43)
2011.year		77.92***	67.11***	108.3***	-611.2	106.9***
		(8,226)	(8,013)	(15.29)	(693.1)	(18.47)
2012.year		77.23***	66.16***	107.5***	-606.5	105.9***
		(8,217)	(8,007)	(15.28)	(687.0)	(18.42)
2013.year		69.74***	57.59***	100.6***	-622.3	99.02***
		(8,177)	(7,980)	(15.44)	(695.7)	(18.65)
2014.year		56.85***	44.69***	85.91***	-637.7	84.33***
		(8,185)	(7,988)	(15.40)	(696.5)	(18.62)
2015.year		39.89***	28.07***	70.19***	-686.2	68.37***
		(8,155)	(7,958)	(16.15)	(726.6)	(19.59)
2016.year		41.47***	29.98***	70.63***	-697.1	66.82***
		(8,296)	(8,109)	(17.07)	(732.3)	(20.41)
2017.year		39.17***	26.86***	69.21***	-705.5	66.08***
		(8,239)	(8,057)	(17.07)	(741.0)	(20.46)
2018.year		39.11***	26.18***	66.53***	-702.2	62.95***
		(8,288)	(8,122)	(16.88)	(733.5)	(20.27)
2019.year		48.31***	34.22***	85.88***	-877.5	82.12***
		(8,538)	(8,387)	(20.43)	(921.8)	(24.82)
Constant	41.22***	17.26***	21.06***	13.51	158.1	9,171

	(1980)	(6,178)	(6,914)	(8,881)	(163.3)	(8,473)
Observations	1,759	1,759	1,759	1,480	1,480	1,480
R-squared	0.027	0.156	0.212	0.153		
Number of Signatures					119	119
Annual Fixed Effects		X	X	X	X	X
Control Variables			X	X	X	X
Instrumental Variables				X	X	X

Source: Authors´ design

*Note: ***- statistically significant at a confidence level of 99% (p<0.01), **- statistically significant at a confidence level of 95% (p<0.05), *- statistically significant at a confidence level of 90% (p<0.1).*

Table 6. Results with SAIFI as the Dependent Variable

VARIABLES (DV: SAIFI)	(1) OLS	(2) OLS	(3) OLS	(4) 2SLS IV	(5) FE	(6) RE
Regulation	-	-	-	-	641.4	-
	14.28***	37.29***	29.97***	80.23***		80.23***
	(1978)	(2,660)	(2,674)	(13.71)	(787.2)	(13.80)
PublicationRegulator			11.36***	4,516	-59.19	4,516
			(2,627)	(4,103)	(92.96)	(4,131)
Public			25.54***	14.05***		14.05***
			(2,306)	(4,474)		(4,504)
2004.year		-0.0163	-0.639	-1,186	-34.70	-1,186
		(6,291)	(6,085)	(7,439)	(47.91)	(7,490)
2005.year		2,358	1,396	1,558	-42.24	1,558
		(6,272)	(6,067)	(7,415)	(57.72)	(7,466)
2006.year		1,810	0.655	-0.0520	-50.74	-0.0520
		(6,216)	(6,017)	(7,369)	(65.87)	(7,419)
2007.year		2,066	0.950	0.306	-50.38	0.306
		(6,198)	(5,999)	(7,369)	(65.87)	(7,419)
2008.year		2,061	0.984	0.363	-45.60	0.363
		(6,181)	(5,982)	(7,278)	(59.01)	(7,328)
2009.year		3,752	2,975	5,247	-72.83	5,247
		(6,150)	(5,954)	(7,278)	(91.51)	(7,328)
2010.year		32.02***	25.90***	69.27***	-581.6	69.27***
		(6,507)	(6,314)	(13.66)	(713.3)	(13.75)
2011.year		57.22***	49.93***	87.82***	-556.5	87.82***
		(6,076)	(5,914)	(11.86)	(707.4)	(11.94)
2012.year		56.44***	49.29***	86.47***	-554.5	86.47***
		(6,054)	(5,894)	(11.86)	(703.6)	(11.94)
2013.year		52.30***	44.95***	83.88***	-566.9	83.88***
		(6,010)	(5,860)	(11.99)	(713.7)	(12.07)

2014.year		40.26***	33.09***	70.74***	-580.5	70.74***
		(5,997)	(5,847)	(11.97)	(714.6)	(12.05)
2015.year		27.30***	19.36***	58.42***	-621.6	58.42***
		(5,995)	(5,846)	(12.57)	(744.8)	(12.66)
2016.year		30.73***	21.21***	60.32***	-630.7	60.32***
		(6,085)	(5,944)	(13.26)	(750.5)	(13.35)
2017.year		28.60***	19.11***	59.22***	-639.7	59.22***
		(6,048)	(5,910)	(13.24)	(761.1)	(13.33)
2018.year		29.81***	19.15***	57.07***	-634.4	57.07***
		(6,085)	(5,960)	(13.10)	(751.4)	(13.19)
2019.year		36.06***	24.04***	73.43***	-798.7	73.43***
		(6,278)	(6,164)	(15.90)	(950.7)	(16.00)
Constant	29.22***	14.78***	1,394	9,126	162.6	9,126
	(1,468)	(4,539)	(5,135)	(6,954)	(187.0)	(7,002)
Observations	1,737	1,737	1,737	1,471	1,471	1,471
R-squared	0.029	0.175	0.230	0.126		
Number of Signatures					118	118
Annual Fixed Effects		X	X	X	X	X
Control Variables			X	X	X	X
Instrumental Variables				X	X	X

Source: Authors´ design

*Note: ***- statistically significant at a 99% confidence level, **- statistically significant at a 95% confidence level, *- statistically significant at a 90% confidence level.*

5 Conclusions

Despite significant heterogeneity between companies, supply interruptions appear as a challenge to be faced by most of them. **From the general population's point of view, one in three LAC citizens is dissatisfied with service quality provided by electricity distribution companies.** Electricity service quality is essential for human well-being and development. Amid the advancement of the new industry 4.0 that appears with digitalization, its importance increases with respect to guaranteeing LAC countries' economic competitiveness.

Regulation plays an important role in promoting better electricity service quality. However, in practice, on the one hand, information asymmetries tend to affect regulators' efficacy. And in parallel, the absence of reliable and comparable information makes it difficult to evaluate the impact of the different types of regulation between different countries in similar situations.

We can measure the evolution of these indicators by relying on the existence of international standards that monitor this type of indicator in almost all countries. As in the rest of the world, most LAC countries have regulation that fosters quality improvement based on monitoring average duration in minutes of interruptions per user in a year (SAIDI or equivalent) and the average frequency of interruptions per user in a year (SAIFI or equivalent).

In addition to monitoring SAIDI and SAIFI indicators, countries also limit the frequency and duration of supply interruptions and financial compensation for customers when the company exceeds such limits. Some countries, such as Brazil and Colombia, have additional instruments, like adopting gradual incentives (or sanctions) concerning improvements (or degradations) in these indicators. In the case of Colombia, the country still provides for the possibility of contracting electricity supply with higher quality standards.

Based on available data, we have analyzed Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Panama, and Peru. Based on the descriptive statistics of the sample of 143 electricity distributors with public data in those countries, it was possible to verify that, on average, SAIDI and SAIFI, after the quality regulation of the electricity supply, have respectively gone from 40.8 to 24.1 hours of outage per customer per year, and 29.7 to 16.2 outages per customer per year.

Our estimates show that quality regulation had a beneficial effect in reducing the duration and average frequency of interruptions per customer in the companies evaluated in the sample. This improvement tends to increase over time.

It is important to note that public companies have a higher SAIDI and SAIFI, on average, according to the descriptive statistics. Still, the dispersion of these indicators is greater in private companies, the latter having the worst performance indicators in the sample. Therefore, comparison between public and private companies in terms of supply performance continuity is not conclusive.

Regarding next steps, it would be interesting to evaluate other variables, such as climate, the existence of an underground network, population income, and the difference between urban and rural regions. Another question that could be evaluated is whether the style of rate regulation (such as *price cap* and *revenue cap*) and the existence of the figure of the electricity marketer alone improve electricity supply quality. Furthermore, it would be interesting to replicate the same type of estimation to assess regulation's effectiveness on company losses. Indeed, the analysis of the impact of these variables on companies' SAIDI and SAIFI could inform the relationship between climatic and socioeconomic issues with the quality of the electricity supply. Studies of this type would also help verify whether it is important to include instruments in quality regulation that make it possible to reduce regional disparities.

The results of this research point to the importance of **implementing regulatory mechanisms for electricity service quality in LAC countries**. However, there are also limits to promoting the quality of electricity services. There are always strategic calculations by regulated agents and complex situations of political economy, mainly when they involve public companies. Incentives for investment in digitization and other new technologies can be complementary mechanisms to achieve sustainable and lasting improvements in service quality.

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Annex. SAIDI and SAIFI by company

Table A.1. The evolution of SAIDI and SAIFI by electricity distribution companies before and after quality regulation.

Country	Year of Regulation	Companies	SAIDI or equivalent		SAIFI or equivalent	
			No Regulation	With Regulation	No Regulation	With Regulation
Brazil	2009	AME		50.21		35.68
Brazil	2009	Boavista	14.24	24.12	32.06	41.99
Brazil	2009	CEA	40.51	61.94	45.96	44.23
Brazil	2009	CEBDIS	13.21	13.74	13.83	11.38
Brazil	2009	CEEED	23.16	19.40	17.86	12.72
Brazil	2009	CELESCDIS	18.10	13.94	13.86	9.71
Brazil	2009	CELGD	23.03	31.40	22.31	20.18
Brazil	2009	CELPE	15.20	18.24	10.20	7.52
Brazil	2009	CEMAR	48.06	17.09	29.57	9.53
Brazil	2009	CEMIGD	12.23	12.11	6.66	5.99
Brazil	2009	CERON	48.06	35.87	58.59	25.30
Brazil	2009	CLOSE	169.93	78.52	20.61	53.72
Brazil	2009	CFLO	3.93	5.21	5.58	5.11
Brazil	2009	CHESP	19.56	14.31	44.79	23.91
Brazil	2009	CNEE	6.32	7.70	9.03	9.67
Brazil	2009	COCEL	14.95	10.86	10.80	8.30
Brazil	2009	COELBA	16.71	20.88	9.45	8.51
Brazil	2009	COOPERALIANÇA	3.89	4.94	3.04	4.19
Brazil	2009	COPELDIS	14.30	11.24	13.36	7.73
Brazil	2009	SEW	12.52	13.51	9.39	7.40
Brazil	2009	CPFLJaguari	6.96	6.40	6.30	5.30
Brazil	2009	CPFLLestePaulista	8.36	8.23	8.71	6.32
Brazil	2009	CPFLMococa	7.35	6.46	8.62	5.79
Brazil	2009	CPFLPAULISTA	6.40	6.94	5.54	4.86
Brazil	2009	CPFLPIRATININGA	7.18	6.85	5.37	4.40
Brazil	2009	CPFLSantaCruz	7.96	6.50	9.61	5.86
Brazil	2009	CPFLSulPaulista	10.32	10.36	9.26	8.03
Brazil	2009	DCELT	9.90	14.06	15.10	15.87
Brazil	2009	DEMEI	11.42	9.91	14.80	11.20
Brazil	2009	DMED	5.43	3.29	6.77	3.01
Brazil	2009	EBO	15.02	7.79	12.12	5.59
Brazil	2009	EDEVP	7.95	6.13	8.86	5.50
Brazil	2009	EDPES	11.73	9.21	8.96	5.67
Brazil	2009	EDPSP	9.77	8.60	7.16	5.48
Brazil	2009	BSE	9.45	12.72	11.58	9.49
Brazil	2009	EFLJC	12.35	3.55	8.03	3.38
Brazil	2009	EFLUL	15.31	7.15	15.59	7.04
Brazil	2009	ELECTRO	10.06	8.44	7.27	4.91
Brazil	2009	ELETROACRE	24.95	53.72	37.93	40.74
Brazil	2009	ELETROCAR	25.15	14.60	25.03	12.57
Brazil	2009	ELETROPAULO	10.25	11.89	6.84	5.46

Figure A.1. The evolution of SAIDI and SAIFI by electricity distribution companies before and after quality regulation.

Country	Year of Regulation	Companies	SAIDI or equivalent		SAIFI or equivalent	
			No Regulation	With Regulation	No Regulation	With Regulation
Brazil	2009	NFE	19.07	8.58	16.75	6.82
Brazil	2009	EPB	35.49	19.46	17.49	9.54
Brazil	2009	EquatorialAL	25.18	31.61	19.25	17.86
Brazil	2009	Equatorial PA	44.43	56.84	37.43	31.36
Brazil	2009	EquatorialPI	49.03	30.88	38.44	21.08
Brazil	2009	THAT	14.47	15.09	10.82	9.01
Brazil	2009	SSE	6.95	7.68	7.97	7.08
Brazil	2009	E.T.O.	44.17	34.14	35.14	17.58
Brazil	2009	FORCE	2.28	1.89	5.42	3.63
Brazil	2009	HYDROPAN	13.00	8.00	18.15	10.88
Brazil	2009	LIGHT	9.20	13.36	6.65	6.80
Brazil	2009	MUXENERGY	19.43	4.11	18.09	3.81
Brazil	2009	GER	19.75	15.36	13.52	8.44
Brazil	2009	RGESUL	19.68	16.30	13.72	8.16
Brazil	2009	SULGIPE	18.85	12.21	19.21	9.92
Brazil	2009	UHENPAL	23.80	16.23	28.12	10.04
Chile	2019	At	6.64		1.52	
Colombia	2008	Codensa		12.61		13.24
Colombia	2008	essa		24.39		20.37
Colombia	2008	Electricaribe	130.00	96.91	83.70	90.20
Colombia	2008	Emcali		18.77		23.90
Colombia	2008	EPM		15.11		22.59
Colombia	2008	Epsa(Celsia)		17.07		20.35
Colombia	2008	yield		82.95		48.76
Colombia	2008	census		32.94		10.39
Colombia	2008	cetsa		5.18		14.34
Colombia	2008	check		33.21		28.00
Colombia	2008	off		73.84		44.61
Colombia	2008	Edeq		11.54		14.36
Colombia	2008	Emsa		18.72		31.81
Colombia	2008	ElectroCaqueta		63.08		66.47
Colombia	2008	CEO		18.72		31.56
Colombia	2008	EECC		82.48		
Colombia	2008	EBSA		12.29		56.68
Colombia	2008	EAF		15.45		12.10
Colombia	2008	Electrofleet		51.40		43.37
Colombia	2008	Enelar		94.16		66.69
Colombia	2008	Enertolima		60.28		112.12
Costa Rica	2015	CNFL	10.29	34.38	12.75	60.24
Costa Rica	2015	COOPEALFARO	29.90	5.37	47.00	6.55
Costa Rica	2015	COOPEGUANACASTE	4.80	6.75		8.40
Costa Rica	2015	COOPELESCA	7.90	9.85	11.00	9.65
Costa Rica	2015	COOPESANTS	1.80	16.63		7.23
Costa Rica	2015	ESPH	5.30	15.65	5.00	7.63
Costa Rica	2015	ICE	14.00	10.22	11.74	8.68
Costa Rica	2015	JASEC	4.93	9.12	6.75	7.15
Dominican Republic	2012	Edenorte	158.62	92.82	46.47	27.17
Dominican Republic	2012	Edesur	161.94	125.27	46.11	32.91
Dominican Republic	2012	EDEEST	137.24	139.75	35.18	
Dominican Republic	2012	CEPM	79.69	124.29	17.55	12.25

Figure A.1. The evolution of SAIDI and SAIFI by electricity distribution companies before and after quality regulation.

Country	Year of Regulation	Companies	SAIDI or equivalent		SAIFI or equivalent	
			No Regulation	With Regulation	No Regulation	With Regulation
Ecuador	2018	CNEL	84.19	11.14	75.71	8.71
Ecuador	2018	CNELGuayaquil	3.37	2.63	5.70	3.50
Ecuador	2018	CNELBolivar	167.43	17.58	111.31	8.84
Ecuador	2018	CNELElOro	104.99	12.79	118.74	14.84
Ecuador	2018	CNELEsmeraldas	181.58	18.14	111.94	13.91
Ecuador	2018	CNELGuayasLosRíos	69.70	14.52	73.82	11.04
Ecuador	2018	CNELLosRíos	157.40	25.45	200.77	14.96
Ecuador	2018	CNELManabí	177.49	8.21	149.52	7.51
Ecuador	2018	CNELMiracle	180.66	17.82	118.15	15.08
Ecuador	2018	CNELStElena	128.55	24.85	98.45	11.09
Ecuador	2018	CNELStoSunday	89.05	4.46	70.79	4.06
Ecuador	2018	CNELSucumbíos	285.14	36.62	207.06	18.52
Ecuador	2018	EEAmbato	53.68	7.18	50.90	5.53
Ecuador	2018	EEAzogues	38.55	7.60	31.19	4.96
Ecuador	2018	EECentrosur	44.28	9.41	27.00	4.48
Ecuador	2018	EECotopaxi	26.39	6.22	28.46	6.77
Ecuador	2018	EEGalapagos	105.31	29.77	71.35	13.03
Ecuador	2018	EENorth	92.04	10.84	60.67	8.56
Ecuador	2018	EEQuito	20.28	1.54	21.57	1.93
Ecuador	2018	EERiobamba	119.33	23.18	54.25	11.52
Ecuador	2018	EESur	53.07	6.70	31.17	5.62
Ecuador	2018	EEPdeGuayaquil	28.22	-	40.42	
El Salvador	2014	CAESS	21.82	8.63	9.87	3.67
El Salvador	2014	CLESA	21.95	11.08	8.13	3.93
El Salvador	2014	DEUSEM	20.21	5.97	10.38	2.38
El Salvador	2014	FROM THE SOUTH	23.32	10.69	10.30	5.39
El Salvador	2014	EEO	27.17	11.08	14.29	3.88
El Salvador	2014	EDESAL	7.14	3.01	4.32	1.72
Panama	2013	ENSA	21.82	36.02	9.87	15.49
Panama	2013	EDEMET	21.95	51.55	8.13	19.56
Panama	2013	EDECHI	20.21	39.29	10.38	19.36

Figure A.1. The Evolution of SAIDI and SAIFI by electricity distribution companies before and after quality regulation.

Country	Year of Regulation	Companies	SAIDI or equivalent		SAIFI or equivalent	
			No Regulation	With Regulation	No Regulation	With Regulation
Peru	2004	EnelDistributionPeru		8.65	2.87	2.86
Peru	2004	Hydrandine		48.17		20.26
Peru	2004	Southeast		35.14		18.32
Peru	2004	Electrosur		15.89		9.62
Peru	2004	Electropuncture		20.32		12.98
Peru	2004	Edelnor			4.46	3.94
Peru	2004	Electrodune		62.14		16.33
Peru	2004	ENOSA				28.03
Peru	2004	SEAL				15.28
Peru	2004	electronorthwest		43.20		43.20
Peru	2004	Electric Society of the South West		21.75		9.89
Peru	2004	Electrocenter		56.48		24.40
Peru	2004	ElectroOrient		23.76		23.76
Peru	2004	Electronorth		25.35		11.68
Peru	2004	ElectroUcayali		14.84		10.33
Total			**40.75**	**24.08**	**29.75**	**16.15**

Source: Authors' design based on companies' and regulators' website information