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Revisiting Private Participation, Governance, and Electricity Sector Performance in Latin America*

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Abstract

This paper revisits the relationship between private participation, regulatory governance and the performance of the electricity sector in 18 Latin American countries over the last five decades. Private investment flows have been consistent overtime, providing around 55% of total electricity investment in the region. We examine the nature, and resultant performance outcomes, of increased private-sector involvement in electricity sub-sectors, including generation capacity, non-conventional renewable energy (NCRE), electricity access, electricity losses, and affordability. The results suggest that private investment and the quality of regulatory governance are positively associated with better performance of the electricity sector. Our long-term examination suggests that private investments strongly contribute to enhancing the quality and efficiency of the electricity sector's performance by increasing generation capacity, increasing the share of renewable energy, increasing access, and reducing electricity losses. Results regarding regulatory quality also indicate a positive association with respect to per capita capacity, electricity coverage, and affordability. Affordability of electricity services also improved in countries with high private participation, while subsidies to the electricity sector declined considerably. These outcomes seem to be enabled and reinforced by independent regulatory governance.

Key Words: Power Sector Reform; Energy Sector Privatization; Regulatory Reform; Latin American Countries; Panel Data Analysis

JEL Classification: Q40; Q48; L50; L94.

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1 Introduction

This paper presents a practical, fact-driven study to inform policy makers in assessing necessary and pending changes in the institutional frameworks for the electricity sector. Region-specific panel data provide new insights into electricity reforms over a longer time period, as well as their impacts on a comprehensive set of sectoral outcomes. Although many significant challenges remain in the Latin America electricity sector, the evidence shows that the region has made important progress over the last few decades. Those advances are rooted in the numerous reforms and self-imposed restrictions to limit the public-sector scope to areas of optimal impact. However, current global trends indicate a swing of the political and economic pendulum towards populist and less-competitive practices, potentially undermining the sustainability of these positive results. The paper also assesses the potential long-term impacts of adapting regulatory frameworks to emerging technologies in the electricity industry.

In the early 1980s, decades of under-investment in the Latin American energy sector, along with an exponential increase in demand, necessitated an urgent political response. This came in the context of severe economic crises, however, and with insufficient fiscal space to invest, governments resorted to inefficient subsidies. The immediate result was further deterioration of electricity services, as well as increased government indebtedness to dysfunctional utilities. In this context, governments turned to extensive regulatory reforms in the sector to increase private participation.

Reforms in the electricity sector have not always been effective or consistent over time. An apparent mismatch between institutional capacity and the process of market restructuring both negatively impacted the early outcomes of the reforms and soured their public perception. Such failures contributed to an already strongly-held aversion to liberal reforms by parts of the Latin American populace, which, in turn, left them vulnerable to instability in the political cycle; in several cases, backlashes ensued, including renationalization and government intervention in supposedly independent regulatory bodies. Such turmoil tends to cloud the verdict on the long-term macro outcomes of re- forms to the Latin America energy sector. There is an overwhelming consensus in the literature regarding the positive effects of the reforms on the quality of services and their contribution to increased economic efficiency; however, there is less

conformity with respect to outcomes such as access and affordability. (e.g., Mookherjee & MaKenzie, 2005; Gonzales-Eiras & Rossi, 2007; Alcazar, Nakone, & Torero, 2007). To address this ambiguity in outcomes, we exploit panel data composed of 18 countries between 1971 and 2016 to gain temporal and cross-sectional variability in terms of the incidence and nature of reforms, as well as the lag time required to assess outcomes.

This paper revisits the link between de jure quality of regulatory governance in Latin America and the impacts on private participation in the electricity sector. We examine the nature, and resultant performance outcomes, of increased private-sector involvement in electricity sub-sectors, including generation capacity, non-conventional renewable energy (NCRE)[1], electricity access, electricity losses, and affordability.

Our results indicate that the regulatory and governance reforms paved the way for the private sector to become a crucial player in the Latin American electricity sector; and that private participation is demonstrably associated with positive performance outcomes, such as improvements in energy security, energy matrix sustainability and overall efficiency. The reforms also contributed to increased per capita generation capacity, greater electricity access, a reduction in electricity losses, and an increase in the share of NCRE. Moreover, affordability levels in countries with high levels of private participation improved with concomitant reductions in electricity subsidies.

The analysis concludes with an updated snapshot of private investment flows in the region by subsector and a review of technological trends and their potential impacts on energy markets. Since 2015, private utilities have accounted for 40 percent of generation and distribution and around 27 percent transmission capacity. Since 1990, private investment has accounted for around US$ 400 billion (expressed in 2010US$), constituting approximately half the total investment in the sector, with 75 percent of that amount invested since the early 2000s, predominantly in the generation subsector. However, the public sector continues to compose a significant part of electricity markets, either complementing private firms under mixed-market scenarios or managing vertically integrated systems.

[1]Non-conventional renewable energy (NCRE) sources include geothermal, wind, solar, and biomass.

The remainder of the paper is organized as follows. Section 2 describes the data. Section 3 presents an overview of the process of regulatory and private participation reforms, including a brief review of the cases of renationalization over the last decade. Section 4 reports the results and examines the long-run relationship between the implementation of these reforms and electricity sector performance in Latin American. Section 5 concludes.

2 Data

This paper adds to a strong and dynamic body of literature that focuses on new, and more consistent, long-term effects on a larger number of outcomes. Broadly speaking, the previous research focused predominantly on OECD countries due to their greater data availability; the research indicated partial efficiency gains from the reform processes across relatively short timeframes (e.g., Foster & Rana 2019; Zang et al., 2008; Andres et al., 2008). Our focus on Latin American countries represents a closer look at a developing region, relying on a more detailed dataset.

In contrast to direct investment, policy reforms may take longer to translate into market conditions and incentives to both attract private partners and allow private investment to come to fruition. For example, in electricity generation, the period for investment to reach maturity can range between four and seven years for technologies such as natural gas or photovoltaic plants. In the case of Latin America, the average year of privatization was 1997, suggesting that results from reforms would start to be discerned and assessed only between 2005 and 2010. Our dataset provides a long-term macro view of the outcomes of electricity reforms by covering approximately ten years before the beginning of the reforms and close to 20 years after the average privatization year, including countries with different degrees of regulatory changes and private participation.

This dataset has been carefully compiled and is an open companion file of this paper. We collected country-year data from different sources to obtain a balanced panel dataset, comprised of 18 countries and encompassing the years 1971–2016. The panel

contains a set of variables on regulatory governance, private investments, performance outcomes, as well as key sectoral and economic characteristics.

Regarding regulatory governance, we constructed a quality index based on studies by Cubbin and Stern (2006), Andres et al. (2008), Domah, Pollit, and Tern, (2002), and Zhang Parker, and Kirkpatrick (2008). These authors identified and gathered data on the following institutional characteristics: presence of an electricity regulatory law; whether the regulator is an autonomous agency or the sector ministry; whether the regulatory agency is funded by a fee originating from license obligation or a line item in customers' electricity bills versus a government budget; and whether the pay scales for regulatory staff are freely set or follow mandatory civil service scales. We updated these data based on information from the countries' ministries and regulators.

The variables on private investment come from the World Bank's Private Participation in Infrastructure (PPI) database, covering electricity projects in generation, transmission and distribution. The PPI database covers investments greater than US$1 million with at least 25 percent private participation under different types of contracts (i.e., management and lease contracts, concessions, greenfield projects, divestiture, public–private partnerships, and joint ventures) for low- and middle-income countries, according to the World Bank classification. We accessed this dataset in mid-2010 and mid-2019 and complemented it with data generated by INFRALATAM[2] as well as by official country sectoral entities.

In addition, we collected data on private participation by national sectoral institutions and utilities in both 2010 and 2015 by subsector. For the generation and transmission sub-sector, private participation is estimated as the share of installed capacity and the share of transmission lines owned by private owners, respectively. For distribution, it is estimated as the share of total electricity demand attended by private utilities. However, for the case of Mexico, Paraguay, Peru and Uruguay, private participation is calculated as the share of electricity billed by private utilities. In

[2]INFRALATAM is a joint initiative developed by the Development Bank of Latin America (CAF), the Inter-American Development Bank, and the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), aimed at developing a database to improve the availability and quality of infrastructure investment data in Latin American and the Caribbean countries (LAC). For details on methodology see http://www.infralatam.info/

the case of utilities with mixed capital (e.g., Colombia, Panama), we considered those with private participation greater than 51 percent as private. Private investments are expressed in 2010 US Dollars.

The outcome variables are (i) per capita generation capacity (MW/million people); (ii) percentage share of non-conventional renewables (NCRE); (iii) rate of electricity access coverage; (iv) electricity losses as a share of electricity output for national consumption; and (v) affordability of average residential and industrial tariffs expressed as the real cost of 1,200 KWh as a share of per capita gross domestic product (GDP). We construct these variables with data gathered from the Economic Commission of Latin America and the Caribbean (ECLAC), the Latin American Energy Organization (OLADE), the International Energy Association (IEA), and official entities and authorities of the electricity sector in each country.

Economic and overall institutional indicators include per capita GDP in 2010 US$, real oil prices, the share of electricity generated with fossil fuels, net oil imports as a share of GDP, urban population share, and political democratic index (Polity IV). Polity IV captures the overall institutional framework, including the strength of institutions, the rule of law and the degree of political interference. These variables were collected from the World Development Indicators, World Bank Commodity Price Data (The Pink Sheet), the Penn World tables, and the Polity IV project.

3 An overview of Electricity Reforms in Latin America: Privatization and Governance

3.1 Reforms in the Electricity Sector

Broadly speaking, Latin America's electricity sector reforms aimed to decouple central government oversight from the day-to-day management and decision-making processes at sectoral authorities and utilities. These reforms were motivated primarily by severe macroeconomic imbalances due to debt crisis and the resultant structural adjustment pro- grams, as well as an increasingly and visibly dysfunctional electricity industry. Overall, the electricity industry was characterized by high levels of political interfer-

ence, with an overlap of the regulatory and managerial roles often seen in nationalized systems. Chronic under-investment and tariff rates assessed below long-term marginal costs resulted in the worst-case scenario of high costs and low productivity. Cash-strapped utilities could not maintain the necessary technical standards to provide commercial service quality. Thus, governments had no choice but to embrace reform in an effort to meet the exponentially expanding energy demands in the region. (e.g., Millan, 2006; Dussan, 1996).[3]

In this context, we can observe three sequential events across countries, representing the typical process of electricity reforms: changes to electricity laws; the establishment of a regulatory entity; and the unbundling and/or privatization of at least one subsector of the electricity system. Table 1 presents the timeline of these key events in the 18 countries analyzed in this paper. In the case of privatization and/or unbundling, we define the main year of privatization as the year in which at least 50 percent of the sector's assets were privatized.

The first episode of an electricity sector reform in Latin America occurred in Chile, beginning in early 1980s and culminating in 1989 with the privatization of all its major utilities (Fischer & Serra, 2004). Most countries began restructuring and reforming their electricity systems in the early 1990s, through the unbundling of vertically integrated state-owned utilities into distinct firms handling generation, transmission, and distribution. This division aimed to foster competition, and facilitate the entry of private investors into the sector. While all countries in the region implemented some degree of regulatory reform, not all engaged in privatization. For instance, Costa Rica, Ecuador, Paraguay, Mexico, and Uruguay; received minimal or no private investment in any of the aforementioned subsectors.

Table 1 indicates that in some countries—namely, the Dominican Republic, Honduras, Nicaragua, Peru and Venezuela—the reform process did not always follow the ideal sequence of implementation, with privatization occurring prior to the establishment of a regulatory agency or a conforming legal framework. Those temporal mismatches generated substantial criticism of the privatization processes being im-

[3]Electricity needs in LAC increased by 5.4% annually, explained mainly by economic expansion, rapid urbanization, and the rise of the middle class between 1971 and 2013 alone. (e.g., Balza et al., 2016).

plemented across the region. Furthermore, even in those countries that followed the 'ideal' order of reforms, it was clear that, due to a lack of profundity or reliability of the new legal or regulatory frameworks, the investment climate remained fundamentally unchanged. As a result, the desired efficiency and/or financial viability gains from energy sector reform failed to materialize. (Foster et al., 2017; Foster & Rana, 2019).

Important differences can be observed in the specificity of energy reforms across countries. Regarding regulatory governance, the level of autonomy varied not only normatively, but also in terms of funding independence and whether staff pay scales were competitive (e.g., Cubbin & Stern, 2006). In the sample of countries analyzed, 13 regulators are considered autonomous, but only seven have funding and pay scales that are independent from those of the government. While institutional arrangements are context-specific, it should be noted that those characteristics are general to the governance of the regulatory bodies and typically considered a signal of their degree of de jure independence.

Table 1: Timeline of Electricity Reforms in Latin America

Country	Reform of electricity law	Regulator established	Main year of privatization
Argentina	1992	1992	1997
Bolivia	1994	1994	1999
Brazil	1996	1996	1997
Chile	1978	1985	1987
Colombia	1994	1994	2003
Costa Rica	1990	1996	NA
Dominican Rep.	2001	1998	1996
Ecuador	1996	1998	NA
El Salvador	1997	1996	1998
Guatemala	1996	1996	1998
Honduras	1994	2014	1999
Mexico	1992	1995	NA
Nicaragua	1998	2008	1999
Panama	1997	1996	1998
Paraguay	1993	1964	NA
Peru	1992	1997	1995
Uruguay	1997	1997	NA
Venezuela	1996	1999	1996

Source: Authors' elaboration based on information from Cubbin and Stern (2006); Andres et al. (2008); Domah, Pollit, and Stern (2002); and ministry and regulators's reports and laws.
Note: NA = Not Apply

3.2 Private Investment Flows in the Latin American Electricity Sector

The cumulative investment in the sector between 1984 and 2016 reached around 400 billion (expressed in 2010 US$), directed mainly towards the generation subsector (see Figure 1, Panel A). This amount represents the purchase of assets, as well as the implementation of investments projects. The introduction of private investment into each subsector was predicated on a number of factors related to the size of the market, investment requirements and political risks. In the case of distribution and transmission, the naturally monopolistic nature of these subsectors, including significant economies of scale and scope, as well as sunk investment costs, discouraged outside investment. Furthermore, in the case of transmission, strategic and security reasons were cited for

maintaining the sector under public control. In the case of the distribution subsector, political considerations, such as rejection by the unions, inhibited private investments in some cases.

Nevertheless, private investment inflows were significant, not just in terms of energy sector reforms, but also relative to the overall economic development and restructuring taking place across the region from the 1980s onward. Figure 1 (Panel B) shows the importance of private investment in electricity relative to total investments in each country (measured as the average of the gross fixed capital formation) over the last three decades. Even countries with dominant public ownership of utilities, such as Mexico and Venezuela, received some private investment, mainly in the generation sector.[4]

At the aggregate level, according to data from INFRALATAM for the period 2008- 2016, the private sector contributed half of the total electricity investment in the region, which, broadly speaking, represents around one percent of gross domestic product annually.

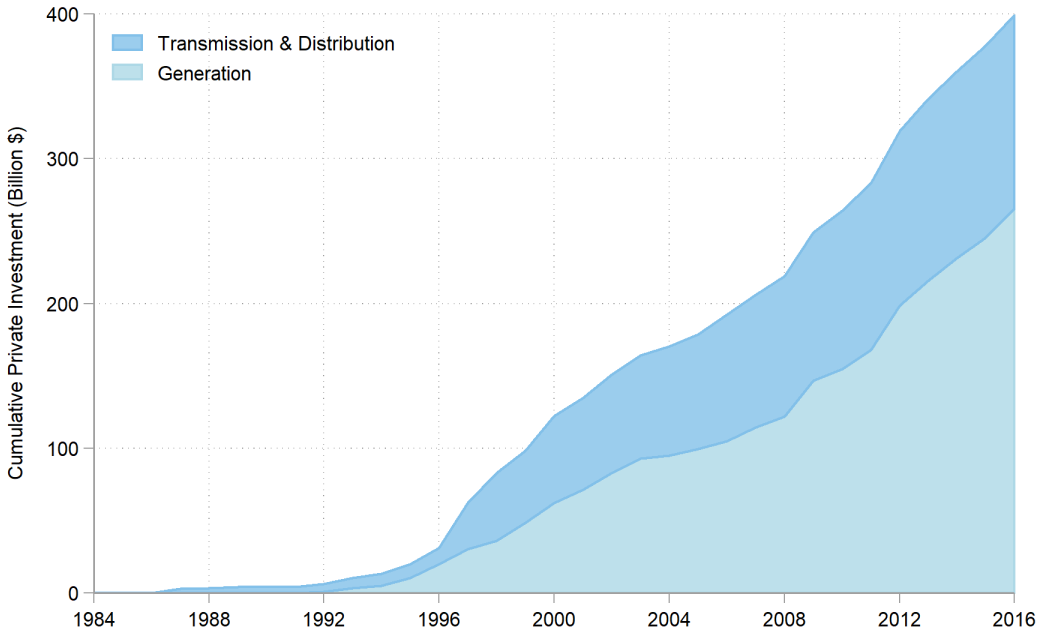
3.3 Private Participation in the Latin American Electricity Sector

The reforms undertaken in the Latin American energy market since the 1980s have completely transformed the configuration of the region's electricity market. Today, private participation accounts for around 40 percent of generation and distribution and 25 percent of transmission. Although most countries still tend to have a significant degree of public participation, with state-owned utilities as key players in the three sub-sectors, there is substantial heterogeneity in market composition across countries. Table 2 presents a snapshot of private participation by subsector in both 2010 and 2015. On the one hand, Bolivia and Chile reached 100 percent private participation

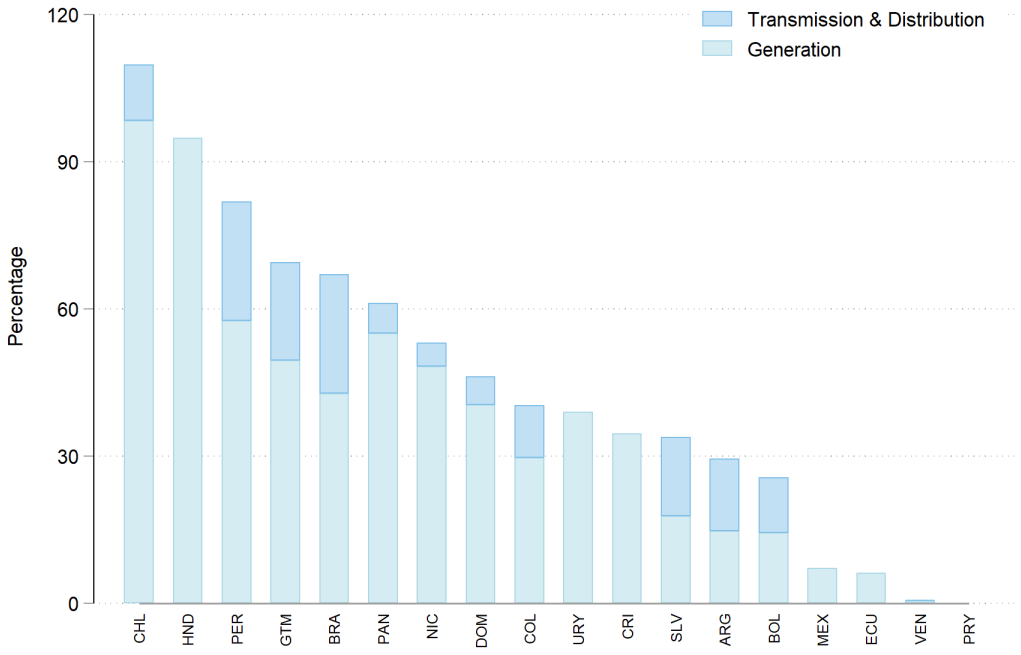
[4] As Figure 1, Panel A shows some private investment occurred in Costa Rica, Ecuador, and Mexico in the generation subsector. In Costa Rica, private investment went mainly to support greenfield projects, adding a capacity of 357 MW through 18 small hydros and four onshore wind projects. In Ecuador, investments added 545 MW through two diesel plants, one large hydro, and one onshore wind project.

Figure 1: Private Electricity Investment Flows, 1984-2016

(a) in Billion US $ 2010



(b) As Percentage of the Average Gross Fixed Capital Formation



Source: Authors' calculations based on data from the PPI Database. World Bank.

Notes: Between 1998 and 2003, Venezuela received a total investment of US$142 million for the privatization of Compania Anonima Luz y Fuerza Electricas de Puerto Cabello, and investments in the electricity system of Nueva Esparta and the greenfield project Aggreko Cadafe Power Station. With the exception of Aggreko, these contracts were all canceled in 2007.

in the subsectors of generation, transmission, and distribution. On the other hand, Costa Rica, Ecuador, Paraguay, and Uruguay had minimal or no private investment in any subsector. Meanwhile, Colombia and Panama have mixed ownership of utilities as a mechanism to boost their financial leverage and managerial capacities.

Greater private participation in generation and distribution has had a positive impact on the adoption of new technologies and managerial practices in those subsectors. Early implementation of NCRE projects in Chile, Brazil, Peru and Uruguay, among others, has taken place mostly through independent power producer models in non- conventional renewables (e.g., Griffith et al., 2017). Similarly, early implementation of distributed generation in countries such as Mexico, Chile, and the Dominican Republic was realized under private participation schemes (e.g., Gischler & Nils, 2011). In the distribution sector, private utilities in Chile and Peru are at the forefront of the deployment of smart grids for electricity demand management.

Table 2: Timeline of Electricity Reforms in Latin America

Country	Generation			Transmission			Distribution		
	2001	**2010**	**∼2015**	**2001**	**2010**	**∼2015**	**2001**	**2010**	**∼2015**
Argentina	60%	73%	73%	100%	100%	100%	70%	66%	66%
Bolivia	90%	34%	18%	90%	87%	14%	90%	82%	49%
Brazil	30%	38%	40%	10%	14%	15%	60%	70%	69%
Chile	90%	100%	100%	90%	100%	100%	90%	100%	100%
Colombia	70%	56%	38%	10%	15%	15%	50%	52%	52%
Costa Rica	10%	18%	19%	0%	0%	0%	10%	0%	0%
Dominican Rep.	60%	83%	71%	0%	0%	0%	50%	0%	0%
Ecuador	20%	17%	12%	0%	0%	0%	30%	0%	0%
El Salvador	40%	68%	71%	0%	0%	0%	100%	100%	100%
Guatemala	50%	77%	87%	0%	36%	33%	100%	93%	90%
Honduras	n.a	63%	79%	n.a	0%	0%	n.a	0%	0%
Mexico	10%	23%	24%	0%	0%	0%	0%	0%	0%
Nicaragua	n.a	78%	83%	n.a	5%	21%	n.a	99%	97%
Panama	n.a	82%	93%	n.a	0%	0%	n.a	51%	51%
Paraguay	0%	0%	0%	0%	0%	0%	0%	0%	0%
Peru	60%	75%	83%	20%	100%	100%	80%	69%	65%
Uruguay	40%	10%	30%	0%	0%	0%	0%	0%	0%
Venezuela	20%	0%	0%	10%	0%	0%	40%	0%	0%
Total	34%	40%	42%	22%	25%	27%	48%	42%	43%

Source: Authors' elaboration based on information from Ministries' and Regulators' reports and from ECLAC. The information for 2001 corresponds to Espinasa (2001).
Notes: For the generation and transmission subsectors, private participation is estimated as the share of installed capacity and transmission lines owned by private owners, respectively. For distribution, it is estimated as the share of total electricity demand attended for private utilities. However, in Mexico, Paraguay, Peru and Uruguay, it is calculated as the share of electricity billed by private utilities. In the case of utilities with mixed capital (e.g., Colombia, Panama), we considered as private those with private participation greater than 51 percent. In the case of the Dominican Republic, there are local independent generators and distributors –located mainly in tourist areas–that account for less than five percent total electricity generated.

Back to Public

As we saw in Table 1, regional data tend to mask the substantial heterogeneity that characterizes the reform process and the resultant penetration of private investment and management across Latin American energy subsectors. The reform process was not always linear, and, in some cases, governments reversed tentative market opening due to inadequate regulatory or legal frameworks. For example, Mexico initiated

reforms in 1992, but for political reasons did not establish private participation in transmission or distribution or deepen reforms in the generation subsector.

As a result, by 2015, private participation in Mexico peaked at 24 percent in the generation subsector, and no private-sector presence can be found in other subsectors. Even in those countries where privatization can be deemed a success, there were often serious difficulties in introducing private investors and consolidating their presence. For example, Alcazar, Nakasone, and Torero (2007) find that the electricity distribution concessions in rural areas of Peru were unsuccessful due to low population density and the difficulty of cost recovery and, thus, necessitated the return to state-owned utilities.

Similar situations are evident in Argentina and Brazil, due to the challenges of financial viability in a market in which subsectors are highly interdependent. Indeed, profitability and soundness of electricity activity depend on the reliability and capacity of generating and transporting electricity, as well as on adequate pricing and efficiency of delivery to final users. The bottom line is that tariffs below cost recovery or high levels of electricity losses affect the capacity of the utilities to remain in business. In some countries, the reforms that occurred in the 1980s and '90s were unraveling by the 2000s; and counter-reforms were adopted that included the renationalization of utilities or increased central government participation in regulatory oversight and supervisory functions. Table 3 presents the timing of the most drastic renationalization processes that occurred in the region.[5] This phenomenon can also be observed in other developing regions (Foster & Rana, 2019) and even seems to form part of growing political trends in developed countries (i.e., Germany, Spain, and the UK).[6] However, in contrast to cases of specific contract cancellations, these latter experiences seem to signal greater political concerns related to the affordability of electricity services.

[5] See Balza, Jimenez and Mercado (2013), a previous version of this paper, for a detailed description of three of the most relevant renationalization cases in the region (e.g., Bolivia, the Dominican Republic, and Venezuela).

[6] See media coverage 1; 2; 3

Table 3: Renationalization of Electric Utilities in Latin America and the Caribbean (1990-2018)

Country	Year	Description
Bolivia	2008	Start renationalization of generation
	2010	State takes responsibility for regulation
	2012	Renationalization of transmission and distribution
Dominican Rep.	2003	Renationalization of distribution utilities
Venezuela	2007	Renationalization of main distribution utility in Caracas
	2009	Merge planning and management activities

Source: Authors' elaboration

Indeed, Bolivia, the Dominican Republic, and Venezuela can be used to describe the non-linear process of country reforms in the electricity sector that occurred in the 1980s and '90s, which later came to unravel. For instance, in Bolivia, the renationalization of the electric system has been part of Bolivia's national strategy to renationalize companies to increase state control over strategic sectors such as natural resources and basic infrastructure services. In fact, President Evo Morales has nationalized the country's gas fields, oil refineries, pension funds, telecommunications, and main hydroelectric power plants, among others. Back in 1995, Bolivia implemented reforms authorizing private investments, with the aim of improving efficiency, reducing marginal costs, and stimulating competition and investments. However, in 2008, the government introduced counter-reforms to reestablish state control in the electricity sector, increasing its participation to nearly 72 percent in the generation sector by nationalizing the assets of Empresa Nacional de Electricidad (ENDE). In 2012, it continued this process by renationalizing most of transmission and distribution. The Bolivian government expropriated the shares of the Transportadora de Electricidad (TDE), which controlled 74 percent of the transmission lines, and began the renationalization of four distribution utilities. These counter-reforms resulted in a decrease in private participation from 90% to 17% in the generation subsector, 90% to 47% in transmission, and 90% to 28% in distribution, between 2001 and 2013.

In 1997, due to several operational and administrative problems, the Dominican Republic began to promote private-sector participation in the generation and distribution sectors, allowing large foreign investments. However, because of the 1999-2001 increase in international oil prices and the country's difficult economic situation, the

government began to subsidize to electricity. This context, combined with the devaluation of the Dominican peso and the increasing debt, caused the sector to collapse. As a result, in 2003, the State acquired 50 percent of the shares of Empresa Distribuidora de Electricidad del Norte (EDENORTE) and Empresa Distribuidora de Electricidad del Sur (EDESUR), and, in 2009, because of another increase in petroleum prices (2006–08), the government purchased 50 percent of the shares in the private company Empresa Distribuidora de Electricidad del Este (EDEESTE), regaining control of the distribution sector.

In the case of Venezuela, there was a gradual opening of the sector to private participation during the 1990s. However, the implementation was slow, and stopped in 1999 when the new administration took office. In 2007, then-President Chávez announced the nationalization of the main energy company in Caracas (Electricidad de Caracas (ELECAR). Petroleos de Venezuela (PDVSA) purchased 82 percent of the shares of ELECAR. As a result of this and other counter-reforms, private participation in the generation subsector fell from 44% to 0%, and in distribution from 45% to 0%, between 1970 and 2010.

4 Private Participation and Performance

This section analyzes the association between market reforms and electricity sector performance, focusing on the following indicators: (i) per capita electricity generation capacity; (ii) the share of NCRE in a country's generation capacity; (iii) percentage of households with access to electricity; (iv) electricity loss as a percentage of total electricity production; (v) affordability of residential tariffs; and (vi) affordability of industrial tariffs.

4.1 Descriptive Graphical Analysis

In Figure 2, we present the relative variation in each outcome variable by the level of private participation. This figure splits the period under analysis into equal time-

elapses before (1978-1997) and after (1998-2016) the average year of reform by degree of private participation.[7]

As the figure shows, the electricity systems with higher levels of private participation tend to present better performance in terms of capacity, access to electricity services and electricity losses. That is, on average, per capita generation capacity and the rate of access to on-grid electricity connections have experienced a more pronounced increase in countries with larger private participation, while their levels of electricity losses have reduced substantially compared to state-owned systems.

Our results on affordability are less consistent. Relative to systems with low private market share, greater private participation seems to be associated with improved affordability levels in the industrial sector but not in the residential sector. For example, for systems with high private participation, in the residential sector, the average real cost of 100 MWh as a percentage of the GDP per capita falls from 63% in the pre-privatization period to 50% in the post-privatization period. In systems with high share state-owned capital, the same ratio fall from 44% to 34%. However, while electricity systems with greater state presence exhibit lower relative cost of electricity and greater reduction in such costs over time (than countries with greater private participation), subsidies are also higher in the former. Therefore, it is very likely that the trend of lower electricity costs in these cases is due, in some degree, to tariffs that were set below costs-recovery levels, a problem that has been extensively documented in countries with predominantly state-owned utilities (Di Bella et al., 2015).[8]

These descriptive results are consistent with the empirical literature, in the sense that private participation has been largely associated with increments in the levels of efficiency of the utilities in deploying and operating investments to support capacity expansion, as well as by increasing the number of connections and reducing electricity

[7]Private participation is set at 1 if the level of private participation in the subsectors of generation and distribution is greater than 50%, or if it is greater than 60% in two of the three subsectors. Transmission was excluded due to low general participation in the privatization process.

[8]It should be noted that the composition of the tariffs on end-consumers used in this exercise are heterogeneous ac cross countries. They typically include subsidies and other components, such as taxes for different segments. Since we are using average electricity tariffs, such heterogeneity could mislead our reading of the effects of privatization if, for example, the tariff formation in a country in more progressive than in another one. See Navajas (2018), and Pastor et al. (2018)) for a glance of the composition of electricity tariff in terms of taxes and fees in Latin America.

losses within the concession areas (e.g., Zhang, 2008; Andres et al., 2009). In addition, this review shows indicators suggesting than affordability have also improved under less reliance on state subsidies.

As an aside, from the above, it may be important to note that the presence of private partners can have an indirect impact on other relevant variables. For example, by liberating fiscal resources from subsidizing the investments and operation of the electricity system, the government can reallocate those resources to necessary public goods in the sector, such as rural electrification, isolated electricity provision, or other social spending.

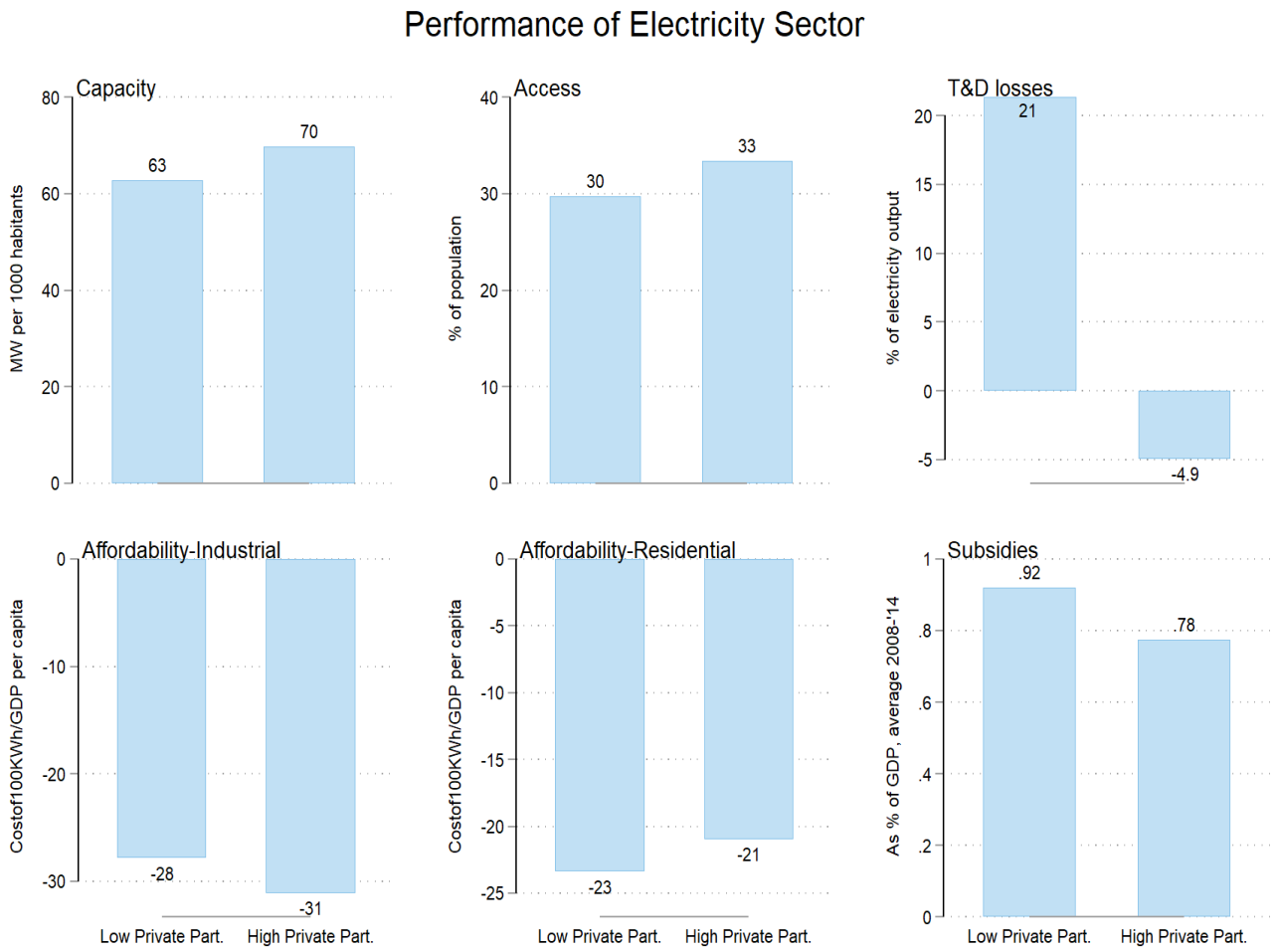


Figure 2: Performance of Electricity Sector by Level of Private Participation (1971-2016)

Note: The figure shows the percentage change in outcomes between the pre-privatization (1978-1997) and post-privatization period (1998- 2016).

4.2 Regression Analysis

In this subsection, we lay down our estimation framework to guide the empirical analysis. We use regression analysis to estimate the conditional correlations between sector performance and market reforms. We evaluate two dimensions of market reforms: quality of regulatory governance and private participation. For the former, following Cubbin and Stern (2006), we consider an additive index of four regulatory characteristics: (i) an electricity law; (ii) independent regulation; (iii) license fee regulatory funding; and (iv) free pay-scale for staff. The variables categorically take the value of 1 if they satisfy the condition in a given year, and 0 otherwise; thus, the index range is [0, 4]. Since it is possible to adopt each characteristic at a different time period in different countries, this institutional index (reg) has temporal variability both within and across our observation units. To account for the time during which the reforms were implemented and had effects on the outcome variables, we introduce a two-year lag in reg[9]. This index allows homogeneous comparison across characteristics among those countries with the key conditions to provide enforcement and credible implementation of the regulatory framework.[10]

We define privatization ($priv$) as the cumulative investment in the electricity sector as a percentage of average real gross capital formation in the period 1984–2016. This variable is intended to capture cumulative private electricity investments from the start of the privatization process. The denominator is fixed by country, as it is intended to scale this investment to the relative size of each economy. Equation 1 presents the proposed specification:

$$Y_{it} = \beta_1 priv_{it} + \beta_2 reg_{it-2} + \beta_3 X_{it} + \omega_i + \varepsilon_{it} \tag{1}$$

[9] Also note that that these variables represent formal attributes of regulation and do not account for informal characteristics, such as transparency or quality of the regulatory process.

[10] These variables represent formal, de jure, attributes of regulation, and do not account for informal characteristics, such as transparency or quality of the regulatory process. This represents a limitation and a potential source of bias in the estimations presented in the next section; however, it allows accounting with homogeneous definitions of institutional characteristics.

where the subscripts i and t denote the country and time period, respectively. Y takes the form of several performance outcomes, such as (i) per capita electricity generation capacity; (ii) the share of NCRE in country generation capacity; (iii) percentage of households with access to electricity; (iv) electricity loss as a percentage of total electricity production; (v) real electricity prices for residential users; and (vi) real electricity prices for industrial users. The regression analysis controls for a set of outcome-specific variables (X) that vary across countries and over time, as well as for country time-invariant characteristics (i). The control set includes: GDP per capita at constant 2010 prices; percentage of electricity generated from fossil fuels; the political democratic index (Polity IV);[11] and international oil prices. The inclusion of these control variables is expected to reduce confounding time-varying country characteristics that may also influence the outcomes of interest. For example, economic conditions are likely to effect energy demand, while natural endowments may influence the country's electricity generation mix and electricity pricing. Similarly, the overall political environment may influence climate investment. All variables, except for the institutional indices, were log-transformed.

It is important to note that transmission and distribution losses are accounted for in the value of overall electricity losses; therefore, we use the corresponding private investments in those subsectors. Also, following Elizalde and Jimenez (2013), the set of control variables for this outcome includes the share of the urban population.

The proposed specification exhibits heteroskedasticity and cross-sectional dependence, which could result in biased estimations of the standard error, leading to an incorrect inference. Also, for all outcomes except the share of NCRE, the specification indicates cointegration.[12] Therefore, we apply Generalized Least Squares (GLS) for all outcomes except NCRE-share, which is estimated to have an autoregressive process in the residuals. Table 4 summarizes the estimations per performance-outcome. For robustness, Panel A shows the estimated coefficient without controls (X_{it}), and Panel B presents our preferred specification (Equation 1).

[11] Polity IV captures democracy and autocracy, ranging from -10 (full autocracy) to 10 (full democracy). We standardize this variable from 1 to 11. These data have been widely used in the political economy and political science arena in an attempt to capture the overall institutional framework dimension.

[12] The test for stationarity is based on the IM-Pesaran-Shin W statistic.

Table 4: Electricity Performance Regressions

	(1) ln(Capacity per capita)	(2) ln(Share of NCRE)	(3) ln(Electricity access)	(4) ln(Electricity lossess)	(5) ln(affordability residential)	(6) ln(affordability industry)
Panel A						
priv	0.125+	0.811*	0.068*	-0.034	0.058ˆ	0.013
	(0.057)	(0.119)	(0.023)	(0.043)	(0.032)	(0.035)
reg_{t-2}	0.086	-0.063	0.052ˆ	0.038	-0.001	0.089+
	(0.064)	(0.048)	(0.025)	(0.029)	(0.036)	(0.036)
Controls	N	N	N	N	N	N
Panel B						
priv	0.069*	0.552*	0.021*	-0.019+	-0.006	0.009
	(0.007)	(0.080)	(0.002)	(0.008)	(0.008)	(0.009)
reg_{t-2}	0.030*	-0.025	0.007*	-0.002	-0.027*	0.008
	(0.006)	(0.093)	(0.002)	(0.006)	(0.009)	(0.009)
Controls	Y	Y	Y	Y	Y	Y
Obs.	792	288	792	792	792	792
Countries	18	18	18	18	18	18
R^2	0.41	0.51	0.58	0.016	0.072	0.18

Source: Authors' calculations

Standard errors in parentheses ˆ p<0.1, + p<.05, * p<.0. All specifications contain country fixed effects.

The results suggest that private investment and the quality of regulatory governance are positively associated with better performance of the electricity sector. In the case of cumulative private investment, an increase of one percent is significantly associated with: (i) a ten-percent increase in electricity generation capacity; (ii) a fifty-percent increase in the share of NCRE; (iii) a two-percent increase in electricity access; and, (iv) a two-percent reduction in electricity losses. No significant results were found on affordability; however, as shown in Figure 2, we observe an improvement in affordability ratios that are less reliant on subsidies. Our results regarding regulatory quality also indicate a positive association with respect to per capita capacity, electricity coverage and residential prices. No significant results were found for NCRE, electricity losses and affordability in the industrial sector. Recall, however, that our index captures only overall characteristics of regulatory governance, which may indirectly affect more-complex dimensions of market performance.

In the case of generation capacity, renewables, and losses, these results capture the direct impact of private investments. With regard to electricity coverage and afford- ability, more-indirect effects may be captured. Growth in electricity coverage in the LAC region is driven by increased urban population density and by rural electrification programs funded by cross-subsidization and/or fiscal resource schemes. Certainly, private participation plays a crucial role in covering urban demand for new electricity connections, while indirectly funding rural electrification programs. In any case, the full impact of private participation needs to be carefully evaluated since most of the rural electrification expansion was linked to government subsidies.

Overall, these results are robust to different evaluation periods and specifications. Annex 1 presents similar results for a shorter time period (1971-2010), for an alternative definition of private participation, using a dummy to indicate the average year of privatization in each country (see Panel A and Panel B, respectively). In the case of the NCRE, however, we found non-statistically significant results, which we attribute to the low variability in the variables for privatization (i.e., in most cases, the privatization dummies mark years when NCRE-shares were small and provide non-variation after that. In the regression for shorter periods, the NCRE-share had little variation across countries and over time before 2010).

5 Concluding Remarks

In Latin America, complex political and economic contexts have led to reform processes that were temporally inconsistent and, in some cases, incomplete, making it difficult to have a clear view of their gains. This paper revisits the outcomes of electricity sector reforms in the region after more than three decades, focusing on regulatory governance and private participation. While both dimensions capture only general features of those reforms, they do allow a more clear and consistent view across the heterogeneous and complex configurations of country-specific electricity markets.

This review shows that electricity reforms changed the configuration of Latin American electricity markets. Based on those reforms, the private sector is, today, a relevant player, constituting more than 40 percent of generation and distribution markets and around 25 percent of transmission activities. In 2015, private investment flows accounted for around 400 billion (expressed in 2010 US$), a total contribution of around 50 percent of total investments in the sector. According to our empirical analysis, electricity reforms also contributed to the improved performance of multiple dimensions of the electricity sector. Electricity sector reforms also delivered greater reliability, sustainability, efficiency, accessibility, and affordability.

Over the coming decade, it is expected that governments in the region will tend to rely heavily on private financing to meet growing electricity investment needs. As described, the private sector has consistently demonstrated a robust investment capacity and has boosted innovation through the implementation of complex activities such as NCRE, net metering, and smart energy systems management. However, our review also suggests that private participation has stagnated over the last decade, and some countries have even reverted to state-owned systems. This represents a potential risk to LAC's growing electricity intensity and energy consumption. It also challenges the ability of governments to ensure an adequate regulatory framework to cope with the structural and technological changes observed in the electricity industry.

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Annex 1

Electricity Performance Regressions

	(1) ln(Capacity per capita)	(2) ln(Share of NCRE)	(3) ln(Electricity access)	(4) ln(Electricity lossess)	(5) ln(affordability residential)	(6) ln(affordability industry)
Panel A: Period 1971-2010						
priv	0.062*	0.062	0.030*	-0.020*	-0.004	0.000
	(0.007)	(0.063)	(0.002)	(0.007)	(0.007)	(0.008)
reg_{t-2}	0.030*	0.004	0.008*	-0.003	-0.028*	0.008
	(0.006)	(0.049)	(0.002)	(0.006)	(0.008)	(0.007)
Controls	Y	Y	Y	Y	Y	Y
Panel B: Period 1971-2016 with privatization dummy						
priv(*dummy*)	0.072*	0.006	0.027*	-0.0046*	-0.021	0.058+
	(0.015)	(0.090)	(0.004)	(0.013)	(0.027)	(0.025)
reg_{t-2}	0.057*	0.005	0.012*	-0.005	-0.029*	0.002
	(0.005)	(0.049)	(0.002)	(0.005)	(0.008)	(0.007)
Controls	Y	Y	Y	Y	Y	Y
Countries	18	18	18	18	18	18

Source: Authors' calculations

Standard errors in parentheses * p<0.1, + p<.05. All specifications contain country fixed effects.