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Provision of Public Services and Welfare of the Poor: Learning from an Incomplete Electricity Privatization Process in Rural Peru

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Abstract[1]

The incomplete privatization of the electric sector in Peru provides a unique scenario for evaluating the impact of public versus private provision. The results in this paper suggest that management of electricity firms by the private sector leads to a significant improvement in the quality of the provision of electricity. These improvements in quality and supply of electricity provision yield some efficiency gains in terms of the time allocation of the working labor force that can be directly linked to the use of electricity. Rural households under private provision of electricity had more opportunities to work in non-farm activities, and as a result, the share of time in non-farm activities increased, indicating both a substitution effect and a potential price effect through higher non-farm wages. The substitution effect implies a reduction of hours spent on farm activities in favor of non-farm activities, and the price effect implies that households will receive higher salaries and therefore will need to work fewer hours in total. As a result, the increase in time spent on non-farm activities was accompanied by a reduction of hours spent on farm activities and an increase in hours spent on leisure.

[1] We are indebted to the excellent research assistance of Lucia del Carpio, Roxana Fernández, Pamela Medina, and David Solis. Any correspondence should be sent to Maximo Torero at m.torero@cgiar.org.

1. Introduction

Since 1990, Peru has embarked upon a drastic stabilization and structural reform process comprising a vast program of privatizing state-owned enterprises, including the main electricity and telephone utilities.

In the electricity sector, the government approved the Law of Electric Concessions (DL 25844) in 1992, which separated power generation from transmission and electricity distribution, vertically unbundling the sector. Prior to the reforms, there were 12 state-owned distribution companies that were responsible for providing electricity service in Peru. In addition to the vertical unbundling, the reforms included the reformulation of tariffs based on marginal costs, the introduction of a scheme of regulated and non-regulated markets, and the privatization of some key electricity assets above. The government also created the Supervisory Agency for Private Investment in Energy (OSINERG) to regulate tariffs and to control the quality and quantity of combustibles and service provision.[2]

Between 1994 and 1997, the government privatized 10 state-owned enterprises—five in electricity distribution and five in electricity generation—for a total of US$1.43 billion. As a result of this privatization process, 66 percent of installed generation capacity (MW) was administered by the private sector by 2005, and 60 percent of production (GWh) and 61 percent of billing came from private companies. In terms of transmission, 100 percent of transmission was managed by private companies by the same year. The billing in this segment was US$122 million. In sum, the private sector served 46 percent of the total number of clients in Peru by 2005 and distributed 71 percent of the energy, which accounted for 67 percent of distribution billing.[3]

Privatization in the distribution segment led to investments of US$838.9 million between 1994 and 2004, representing 61.27 percent of total investments reported in the same period (Appendix 1, Table A.1 details the investments that took place by company). As shown in Table 1, by the end of 2005 Peru achieved a national electrification coefficient of 78.1 percent, up from the 56.8 percent reported in 1993, with generation capacity increasing by 67 percent during the same period. Electrification rates, however, still differ significantly among regions, in particular between the urban and rural sectors.

[2] "What is OSINERG: Institutional Information." http://www.osinerg.gob.pe/osinerg/informa/qosinerg.jsp).
[3] "Anuario Estadístico 2005." OSINERG—Gerencia Adjunta de Regulación Tarifaría División de Distribución Eléctrica, 2006.

Table 1. Peruvian Electricity Sector Main Indicators

General Indicators	1993	2005
Power capacity (MW)	4,282	6,201
Production (GWh)	14,678	25,510
Energy provided (GWh)	8,311	20,701
Number of clients	2,104,868	3,977,100
National electrification coefficient (%)	56.80%	78.1%
Distribution loss (%)	21.80%	8.41%
Investment (US$ millions)	174	393

Source: Ministry of Energy and Mines (MEM).

The incomplete privatization process has led to the existence of selected private provision areas while the rest of the country remains served by state-owned companies, but the National Rural Electrification Plan has promoted a broad range of initiatives since 1993 that target the poorest areas.

Unlike other experiences, the incomplete privatization of the electric sector in Peru provides a unique scenario by which to evaluate the impact of public versus private provision of public services within the same country. This scenario allows us to compare differences in access, service quality, and other outcomes of the provision of electricity for the rural poor. In particular, taking advantage of available data collected through a specialized electricity and energy household rural survey, we will be able to compare differences in welfare between people with private provision of electricity and people in regions where electric companies were not privatized.

Moreover, besides analyzing the impact on direct consumer welfare, this study also examines other indirect impacts such as the type of energy sources used by consumers in privatized versus non-privatized areas, the effects of better quality of electric service on time devoted to non-agricultural activities, and the effects on time devoted to economic and non-economic activities of rural households.

The paper is divided into the following sections. The second section describes the incomplete privatization process and specifically explains how it can be used as an experiment to evaluate the impact of public and private provision of electricity on households. Section 3 describes the specialized survey and electricity database used by the study, and Section 4

describes the econometric techniques used to compare households with private provision versus public provision. Section 5 then presents the major findings, and Section 6 outlines some preliminary conclusions.

2. Overview of the Privatization of the Electric Sector in Peru and the Dynamics of Public and Private Operators

2.1. The Privatization Process

The privatization of the electric sector in Peru took place within a broader privatization process that started in 1991 with the Law for the Promotion of Private Investment in State Enterprises (DL 674). An ad hoc commission, COPRI, was created to conduct the whole process, and three special committees (CEPRIs) were formed to conduct specific processes within the electric sector (Electrolima, Electroperu, and Regional Electric Companies).

In addition, the electric privatization process was conceived as part of a broader reform of the electricity sector, introduced with the Law for Electric Concessions (1992). As a result, state-owned companies were spun off in that same year into several smaller companies, in the distribution, transmission, and generation segments, to fulfill the vertical unbundling clauses of the law and to provide some basis for yardstick competition. Four companies were created to serve the distribution market in Lima, and other regional companies were designed to cover broader geographical areas, as shown in Table 2.

As detailed in Figure 1, the privatization of the electric sector started in 1994 with the distribution companies Edelnor and Edelsur (later Luz del Sur), both with concession areas in Metropolitan Lima, and then continued with Ede Chancay and Ede Cañete in 1995 and 1996, respectively, which served the provinces of Lima and which were acquired by the same economic groups controlling Edelnor (Ede Chancay) and Luz del Sur (Ede Cañete). As a result, the Lima area is basically 100 percent covered by privatized companies.

The privatization of the electricity distribution companies in Lima mainly consisted of the sale of a 60 percent stake to a private strategic operator, while 10 percent of capital was offered to the companies' workers, and the remaining 30 percent was sold on the stock market (with the exception of Ede Cañete, which was totally sold to Luz del Sur). Clearly, the main objective of these processes was to maximize the proceeds of the sale for the Peruvian government.[4]

[4] In all cases, the selection process consisted of two main stages. In the first stage, bidders had to pre-qualify based

Table 2. Public Company Spin-Offs

Public Company Spin-offs	Segment	Concession area (only for distribution)	CEPRI
ELECTROLIMA			
EDELNOR	Distribution	Metropolitan north of Lima, Callao, Huaura, Barranca, Huaral and Oyón	CEPRI ELECTROLIMA
EDELSUR	Distribution	Metropolitan south of Lima	
EDE Chancay	Distribution	Chancay (Huacho, Huaral and Super)	
EDE Cañete	Distribution	Cañete	
EDEGEL	Generation		
ELECTROPERU			
EGENOR	Generation		CEPRI ELECTROPERU
CAHUA	Generation		
ETEVENSA	Generation		
EEPSA	Generation		
REGIONAL COMPANIES			
ELECTRO SUR MEDIO	Distribution	Ica, and part of Huancavelica and Ayacucho	CEPRI REGIONAL COMPANIES
ELECTRO NORTE MEDIO	Distribution	La Libertad, Ancash and part of Cajamarca	
ELECTRO CENTRO	Distribution	Huánuco, Pasco, Junín, and part of Huancavelica and Ayacucho	
ELECTRO NORTE	Distribution	Lambayeque, Cajamarca and Amazonas	
ELECTRO NOROESTE	Distribution	Tumbes and Piura	
ELECTRO SUR	Distribution	Tacna and Moquegua	
ELECTRO SUR OESTE	Distribution	Arequipa	
ELECTRO SUR ESTE	Distribution	Puno, Cuzco, Apurimac and Madre de Dios	
EGEMSA	Generation		
EGASA	Generation		
EGESUR	Generation		

Source: COPRI

The CEPRI for the regional electricity companies was created in 1996 initially to manage the privatization of the eight state-owned regional distribution companies: Electro Sur Medio, Electro Norte Medio, Electro Centro, Electro Norte, Electro Noroeste, Electro Sur, Electro Sur Oeste, and Electro Sur Este.

on financial indicators and credentials; sometimes no previous experience was required. Then, competition in the second stage was based on the economic offers of qualified bidders. The competitive factor used was the largest payment over a price pre-established by COPRI (between US$8.2 and US$129 million, depending of the size and importance of the company).

The privatization of Electro Sur Medio took place in 1997, followed in 1998 by the joint privatization of Electro Norte, Electro Norte Medio, Electro Noroeste, and Electro Centro. Electro Sur Medio was awarded to the HICA consortium of the Argentine IATA and the Peruvian C. Tizon, Amauta Industrial, S&Z Consultores Asociados, and Constructores Vásquez Espinoza S.A.; while Electro Norte, Electro Norte Medio, Electro Noroeste, and Electro Centro were awarded to the Peruvian firm J. Rodríguez Banda S.A- JORBSA (Gloria group).

The privatization scheme designed for the regional electricity distribution companies differed from the processes handled in Lima. With the objective of promoting electrification in unserved areas, the model included investment commitments of US$25.64 million to expand the electrification frontier in the case of Electro Sur Medio, representing 50 percent of the total payment, and no investment commitments but an obligation to serve any potential demand under a delimited area of influence in the case of the group of regional companies in the north and center.

Table 3. Privatized Companies, Terms of Privatization

Company	Date	Price (US$m)	Terms (controlling stake)
Edelnor	July 1994	209.3	Sale of 60% stake to Inversiones Distrilima (controlled by Endesa (Spain), Chilectra, and Enersis (Chile) and Cosapi (Peru)). Cash. No investment commitments.
Luz del Sur	July 1994	406.9	Sale of 60% to the Ontario Quinta consortium. Cash. No investment commitments.
Ede Chancay	December 1995	10.5	Sale of 60% to Edelnor. Cash. No investment commitments.
Ede Cañete	June 1996	8.6	Sale of 100% to Luz del Sur. Cash. No investment commitments.
Electro Sur medio	February 1997	51.28	Sale of 98.2% to HICA Consortium. 40% cash (20% upfront and difference in eight years); 50% through investment commitments in rural electrification; 10% to be shared with workers.
Electro Norte Medio Electro Centro Electro Noroeste Electro Norte	November 1998	67.88 32.69 22.88 22.12	Sale of 30% to JORBSA (10% upfront and difference in 12 years). An option to acquire an additional 30% of the company was included. No investment commitments but with the requirement of operating rural electrification projects handled by the DEP under their area of influence.

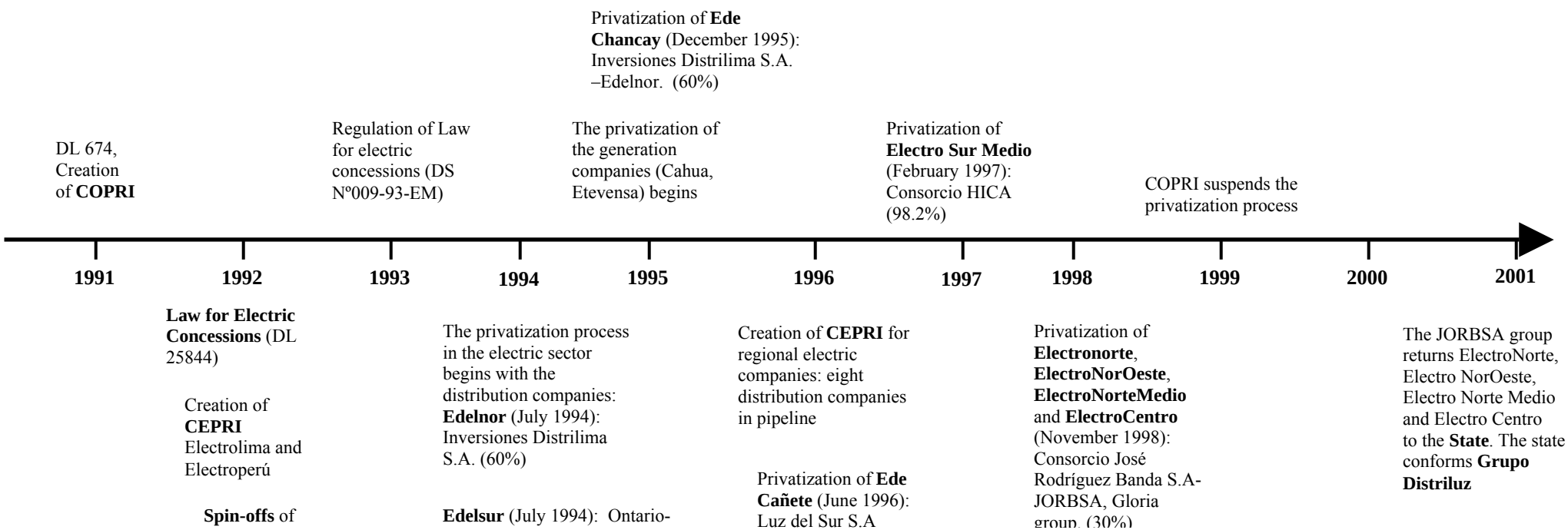
Source: COPRI.

In 1999, during the process of privatizing EGASA, the state-owned company controlling the southern region of Arequipa's main hydroelectric plant, popular disturbances impeded the adjudication of the company and led to an interruption of the whole privatization process. Electro Sur, Electro Suroeste, and Electro Sureste therefore remained in public hands.

The privatization process suffered an additional downfall when Electro Norte, Electro Noroeste, Electro Norte Medio, and Electro Centro were returned to the state by the JORBSA group in December 2001. The government then began to design a new privatization process for the same companies in 2002, which is why the companies have maintained their private structure, operating together under the name "Distriluz," outside of the common legal framework for public companies. For instance, their investments do not enter into the national public investment system, nor are they subject to the government procurement laws governing the other public companies. (More information is provided in Section 2.3.)

Figure 1.

Privatization Timeline for Distribution Electric Companies



Source: COPRI.

2.2 Provision of Electricity in Rural Peru

The state embarks upon rural electrification projects in order to provide energy to people who are not served by the existing electrical system because of the distance and lack of accessibility of their dwellings. Most of the time, it is not profitable for the existing companies to supply energy to these areas because of the huge investment needed, so public intervention is essential.

To address the problem of rural electrification, a special division within the Ministry of Energy—the Executive Directorate of Projects (DEP)—was created in 1993 to handle energy projects and extend the electrical frontier. The DEP received the mandate to create, fund, and implement the National Rural Electrification Plan (and to update it annually during a 10-year timeframe).

In 2002, a specific law promoting rural electrification was passed (Law 27744) creating a fund for rural electrification under the administration of the DEP and defining criteria for the National Rural Electrification Plan. However, the law was inapplicable given its reported contradictions with the Decentralization Law (Law 27783) and the Organic Law of Regional Governments (Law 27867), and because it was too general in various aspects. Recently, a new general law of rural electrification (Law 28749-2006) was enacted to replace the previous one. This new law is more extensive, more clearly defines the Rural Electrification System, and extends the sources of financing (for example, from 2 to 4 percent of the profits of the electrical companies, and consumer contributions of 2/1000 of 1 UIT[5] per MWh consumed). Also, the Law involves a systematic effort to organize rural electrification works through the National Rural Electrification Plan, considers the role of ADINELSA, and includes an entire section on promotion of private investment in rural electrification.

Peru's rural sector's electrification rate was estimated at 32 percent in 2002, up from a reported 5 percent in 1992. Rural areas adjacent to urban centers have benefited from the expansion of the electrification frontier by distribution concessionaires following the reforms introduced in the sector since 1992, but some of the poorest and most remote areas in rural Peru have also found access to the service as a result of a broader range of initiatives fueled by other sources, mainly the National Rural Electrification Plan. The expansion of the electrification frontier by concessionaires and by all these alternatives, however, has not been part of an

[5] The Unidad Administrativa Tributaria (UIT) is a tax-related reference unit. As of September 2006, the value of one UIT is around US$1,045.

organized and systematic plan and, therefore, information on the importance of the various modalities of service provision and their results is limited.

From its creation in 1993 to 2004, the DEP invested US$552 million in rural electrification, providing 4.9 million inhabitants with access to electricity. The works are financed with its own resources (including income from privatizations) and with external contributions. The DEP engages directly in the construction of infrastructure and then transfers the operation and maintenance assets to several different actors including distribution companies (when the project is under their concession area) or to ADINELSA, a public holding created to find an operator for built infrastructure (when the project is outside of concession areas). Since it became operational in 1998, ADINELSA has mainly transferred networks and systems to the distribution companies that currently operate under Distriluz (Electro Noroeste, Electro Norte, Electro Norte Medio, and Electro Centro) because of commitments in the privatization contract and has also promoted the creation of municipal or communal-based units to operate other infrastructure. These operations are usually not profitable, so ADINELSA provides the necessary subsidies to the operator (from a fund based on contributions from concessionaries).

Public efforts to promote rural electrification have not only consisted of investing in rural electrification projects but also of establishing a new tariff structure to make electricity affordable for the poor. In August 2001, the Peruvian Congress passed legislation to establish a "social tariff" for electricity consumption. The enacted law created the Social Compensation Fund (FOSE), a cross-subsidy that benefits final users who consume less than 100 KWh per month by providing them with a discount that varies depending on predetermined ranges of consumption. This fund is financed by a 3 percent tax on final users who consume more than 100 KWh per month. The FOSE differentiates tariffs not only with respect to the quantity of Kwh consumed but also to the area of consumption, providing more benefits to rural consumers. Although the FOSE was originally envisioned to be applied for only three years, Congress indefinitely extended the application of the subsidy in July 2004.

Table 4. FOSE Subsidy Classifications

Users	Sector	Tariff reduction for consumers =< 30 kWh-month	Tariff reduction for consumers > 30 kWh-month up to 100 kWh-month
Interconnected Systems	Urban	25% energy charge	7,5 kWh-month
	Urban–rural & rural	50% energy charge	15 kWh- month
Isolated Systems	Urban	50% energy charge	15 kWh- month
	Urban–rural & rural	62.5 energy charge	18,75 kWh- month

Source: Law N° 28307 – 07.28.04

2.3 Public versus Private Provision of Electricity

Of the 22 distribution companies currently regulated by OSINERG, nine were privatized (of which five remain private and four were returned to the state after three years of private management); seven have always been public; and six are new private companies created after the reform of the sector. Map 1 and Table 5 present the concession areas showing a scenario of multiple operating models in the provision of electricity in Peru, which forms the basis of this evaluation of the impact of privatization.

Currently, electricity in Peru is provided through two main actors: (i) the traditional spun-off state-owned distribution companies; and (ii) privatized distribution companies. In addition, a few new private distribution companies have been established, under operating models which include schemes of subsidized electricity infrastructure investment, defined and carried out through governmental and non-for-profit institutions, which are later transferred for their operation to existing distribution companies or newly created units at local governments. Municipal or community-based operating units have also appeared as the result of the Decentralization Laws.

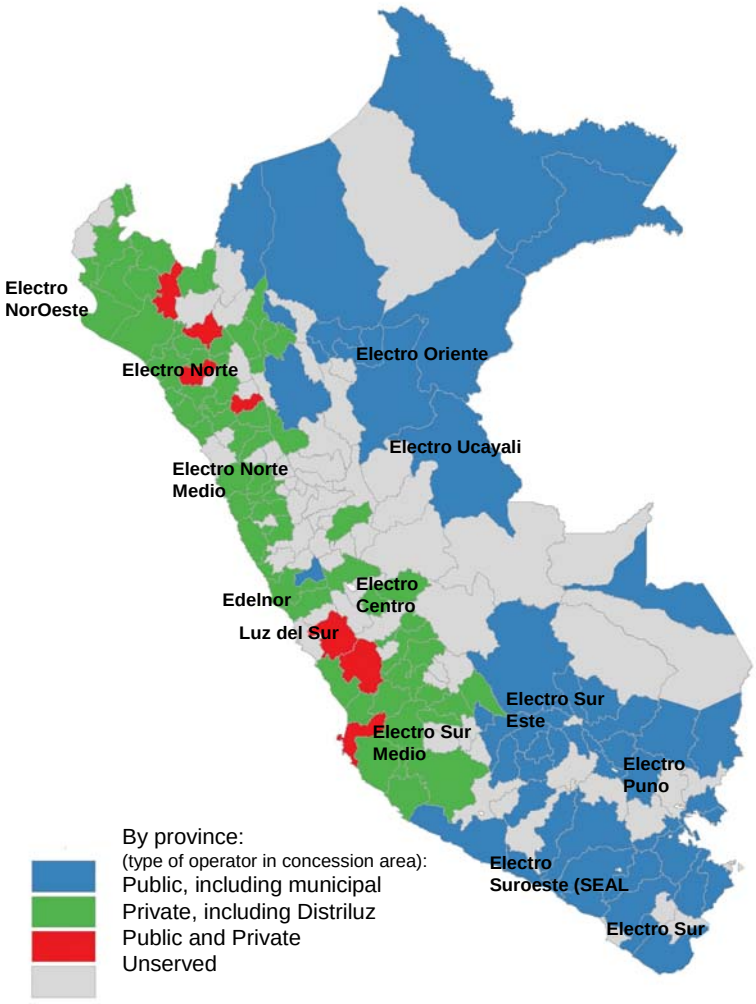
Table 5. Distribution Companies

Company	Property	Number of customers	Concession Areas
Consorcio eléctrico de Villacuri S.A. (Coelvisa)	Private	644	Lima, Ica and Huánuco
Electro Paramonga	Private	5,687	Paramonga
Electro Utcubamba (Emseusa)	Private	4,902	Utcubamba
Electro Pangoa	Private	1,033	Pangoa
Electro Rioja	Private	4,087	San Martin
Electro Tocache	Private	7,114	Tocache
Ede Cañete	Privatized	25,978	Cañete
Edelnor	Privatized	912,186	Metropolitan north of Lima, Callao and the provinces: Huaura, Barranca, Huaral and Oyón
Edechancay	Privatized		Chancay (Huacho, Huaral and Supe)
Electro Sur Medio	Privatized	123,311	Ica, and part of Huancavelica and Ayacucho
Luz del Sur S.A.	Privatized	719,651	Metropolitan south of Lima
Chavimochic	Public	3,316	La Libertad
Electro Oriente	Public	126,581	Loreto, San Martin
Electro Puno	Public	115,656	Puno
Electrosur	Public	95,896	Tacna and Moquegua
Electro Sur Este	Public	228,696	Puno, Cuzco, Apurimac and Madre de Dios
Electro Ucayali	Public	41,811	Ucayali
Electrocentro	Mixed**	364,957	Huánuco, Pasco, Junín, and part of Huancavelica and Ayacucho
Electro Norte Medio-Hidrandina	Mixed**	396,563	La Libertad, Ancash and part of Cajamarca
Electro noroeste	Mixed**	228,753	Tumbes and Piura
Electronorte	Mixed**	218,346	Lambayeque, Cajamarca and Amazonas
Sociedad Eléctrica del Sur Oeste	Mixed**	234,477	Arequipa
Total		3,859,645	

**Privatized and returned to the State

Source: OSINERG and MEM.

Map 1.
Map of Main Distribution Companies' Concessions



Source: MEM.

The penetration of both state-owned and privatized distribution companies has been significantly shaped by the structure of the electricity sector as conceived by the Law for Electric Concessions, which grants zonal concessions to the main distribution companies. In essence, there is one operator per concession area to achieve economies of scale, and a requirement to provide service to whomever requires it within the concession area and to facilitate installations

for other operators that require it (within a one-year period). Expansions in these areas have been achieved mainly through connecting new users to the national grid.

Other actors, however, such as newly created private companies and municipal entities, operate under different incentives schemes. Private companies have mainly been created to supply the electricity demand of selected agricultural and other business-related areas, while municipal and community-based initiatives have been developed as a result of national or municipal endeavors of various types—mainly to serve the most remote areas. Since the enactment of the 1992 Law, only six new private companies have been created and are almost exclusively oriented to the business sector (not residential). In contrast, there is evidence of a significant number of small municipal and community-base initiatives. Most of these access gains have been achieved through the construction of small and isolated power systems.

Classifying State-Owned Distribution Companies and Privatized Companies

This paper classifies as public distribution companies those that have always been in public hands. As shown in blue in Map 1, they are the following: Electro Sur, Electro Sur Este, Electro Puno, Electro Ucayali, and Electro Oriente. Through concessions, these companies cover more 450,000 square kilometers in Peru's coastal, Andean, and jungle regions and, as of December 2004, served 843,000 clients (representing 22 percent of the total). These companies have expanded to rural areas within their concession areas. In addition, the DEP has transferred several projects to them within the framework of the National Rural Electrification Plan.

Private companies, on the other hand, need to be classified into two groups:

i) Electro Norte, Electro Norte Medio, Electro Nor Oeste, and Electro Centro (together Distriluz), which were privatized and remained in private hands for three years before being returned to the state in 2001. The Distriluz companies have concession areas in Peru's northern coast and the central Andean region, covering 180,200 km and serving 1.2 million clients by the end of 2004 (31 percent of total clients in the country);

ii) Companies that were privatized and are still private, i.e., Edelnor, Luz del Sur, Ede Cañete, and Electro Sur Medio. These companies cover 40,584 square kilometers in concession areas and serve 46 percent of total clients.

The "Distriluz" companies constitute a peculiar case that deserves further analysis to determine its classification as private or public. As mentioned before, these public companies were privatized in 1998 as part of the privatization process. While these companies were in private hands—the Rodríguez Banda Group (JORSA–Gloria Group)[6]—important changes took place, resulting in a significant reduction of electricity losses in distribution,[7] for example, and a reversal of negative financial balances. A few years later in 2000, however, the Gloria Group argued that it could not afford to fulfill its investment commitments. After negotiations, an arrangement was made and the Gloria Group returned control of the four companies to the state. They were registered as the "Distriluz" group in 2001 (having a single directory and sharing policies as they did when in private hands). It is formally a mixed company, but private firms have only very minor participation.[8] Nonetheless, Distriluz is treated by the regulatory agency OSINERG and the tax agency as a private firm and is not required to comply with other public firms' regulations (Law 674), such as registration and approval of investments by the National Public Investment System (SNIP) or observance of the State Contracting and Procurement Law or the Public Indebtedness System. Furthermore, as Distriluz directors and personnel are hired through private contracts, its labor regime is based on Law 728, which regulates the activity of private firms, and the companies manage their own budgets.

This arrangement was possible because of a special exclusion norm (COPRI 363) that allowed the Distriluz group to keep a private regime because it was supposed to return to private hands within a short period. However, the exclusion norm has been renewed every year since the return of Distriluz to public ownership. This situation is very peculiar, as it is the only case of a public company that functions under private market rules.

Under their privatization contract, the Distriluz companies (unlike other private distribution firms) were required to provide electricity service not only in their concession areas but also, if required, in a larger area of influence (mostly rural), which was defined in the contract. As a result, these companies operate in various rural areas (Table 6). In addition, and as shown in Table 7, the companies have also received several electricity distribution networks

[6] And other minor private partners, most of whom are still shareholders.
[7] Distribution energy losses were 18.68 percent in 1998 and were reduced to 9.88 percent by the end of 2001.
[8] Electronoroeste and Electrocentro are 100 percent public, while Electronorte is 99.99 percent public; in the case of Hidrandina, 5.3 percent of total shares are in private hands.

built-up by the DEP under the auspices of the National Rural Electrification Plan, for operation and maintenance purposes.

Table 6. Number of Customers in Rural Areas (2005)

EMPRESAS	Interconnected systems	Isolated systems	TOTAL
Edecañete	5,735	71	5,806
Electro-Oriente	0	2,824	2,824
Electro-Puno	4,589	1	4,590
Electro-Sur-Este	128,668	0	128,668
Electro-Sur-Medio	9,610	1,152	10,762
Electro Ucayali	654	0	654
Electro-Centro	170,118	5,642	175,760
Electro-Nor-Este	28,039	301	28,340
Electro-Norte	12,779	25,653	38,432
Electro-Sur	9,678	0	9,678
Emseusa		4006	4,006
Hidrandina	41,240	9,023	50,263
Seal	15,775	5,011	20,786
Otros	41,300	25,416	66,717
TOTAL	**468,185**	**79,100**	**547,286**

Source: OSINERG.

In the Lima area, Edelnor and Luz del Sur have reached an almost 100 percent coverage of their concession areas, involving some rural areas. In addition, both companies have expanded their influence to nearby rural areas in some provinces of Lima (Table 6). No transfers from DEP/ADINELSA have been reported.

Table 7.
DEP and Adinelsa Rural Projects' Transfers to Distribution Companies

Company	Number of rural projects transferred by	
	DEP	ADINELSA
Electro Sur Medio	16	n.a.
Coelvisa	n.a.	2
Electro Tocache	n.a.	2
Electro Norte Medio	39	n.a.
Electro Norte	32	38
Electro Centro	42	28
Electro Noroeste	24	8
Electro Sur	14	n.a.
Electro Suroeste	44	n.a.
Electro Sureste	74	n.a.
Electro Oriente	46	10
Electro Ucayali	16	n.a.
Electro Puno	20	n.a.
Municipalities	32	38

Source: DEP and ADINELSA.

In the immediate southern environs of Lima, Electro Sur Medio has contributed to the electrification of rural areas such as Huancavelica and Ica as part of its investment commitment (US$25.64 million). In addition, the DEP has transferred a few rural projects to the company for operation and management.

Finally, municipal and community-based electricity operations have been reported to exist in various areas across the country. Some of these operations have their origins in the National Rural Electrification Plan carried out by the DEP, while others originate from other initiatives such as the external cooperation mandates of international financial institutions. Given that in most of these cases, the scope of the distribution service is under the 500Kw limit required to be a concession, it is difficult to identify them extensively. Furthermore, based on the survey under study,[9] their coverage is still limited (covering only around 3 percent of clients).

[9] National Survey of Rural Energy Demand.

In summary, this scenario of multiple operating models providing electricity in rural Peru provides a unique opportunity to evaluate differences in households' welfare resulting from private versus public provision of the service.

3. Data

One of the major characteristics of the privatization processes is a lack of detailed pre- and post-privatization information on the privatized firms. Our advantage is that we have access to a representative survey of electricity and energy use in rural Peru. Specifically, the sample universe for the survey includes all communities in Peru with a thousand or less households, whether rural-dispersed, semi-rural or peri-urban. This survey was implemented during June and July of 2005 in the 24 departments of Peru. The survey includes two components: Population centers (communities) in each dominion of the study (446), and 6,690 the households .

The survey is representative of seven subregional divisions: Costa Norte (Northern Coast); Costa Centro (Central Coast); Costa Sur (Southern Coast); Sierra Norte (Northern Andean Region); Sierra Centro (Central Andean Region); Sierra Sur (Southern Andean Region) and Selva (Amazon region). The sampling size is distributed according to Table 8.

Table 8. Distribution of the Sample Size

Dominium	Sample Conglomerates	Sample Houses	Expected Standard Deviation (cv)
Total	**446**	**6,690**	
COSTA NORTE	64	960	0.032
COSTA CENTRO	64	960	0.050
COSTA SUR	48	720	0.038
SIERRA NORTE	66	990	0.021
SIERRA CENTRO	68	1,020	0.029
SIERRA SUR	68	1,020	0.024
SELVA	68	1,020	0.022

The advantage of the survey is that it not only contains the traditional questions found on an LSMS survey (which provide us with sufficient variables to use in the matching procedure), but that it also contains specific modules on electricity and energy consumption, which allows us to answer the main questions of this study. Specifically, the survey includes information on the

households' sources of energy, and it collects detailed information on the provision of electricity for the households connected to the grid. For these households, the survey collects information on the name of the distribution company (crucial in identifying areas where privatized companies are operating) and the year in which the household was connected to the grid, details on consumption and the last three electric bills, number of hours in a day households had access to service, and quality of service provision.

Based on the information obtained from the survey, and following the previous classification of private and public distribution companies, we observe that 24 percent of the households are served by private distribution companies; 15 percent are served by public companies; 3 percent are served by other models including regional, municipal, and communal operations; and the rest do not have access to electricity. It is also important to note that an important percentage of the households served by private distribution companies—16 percent—is served by the Distriluz group's regional distribution companies, which, as noted above, are no longer private but still retain some private elements.

Based on survey information, Map 2 shows the geographic location of the private and public operators and the number of observations. It is clear that private operators are mainly located in the coastal and central Andean regions.

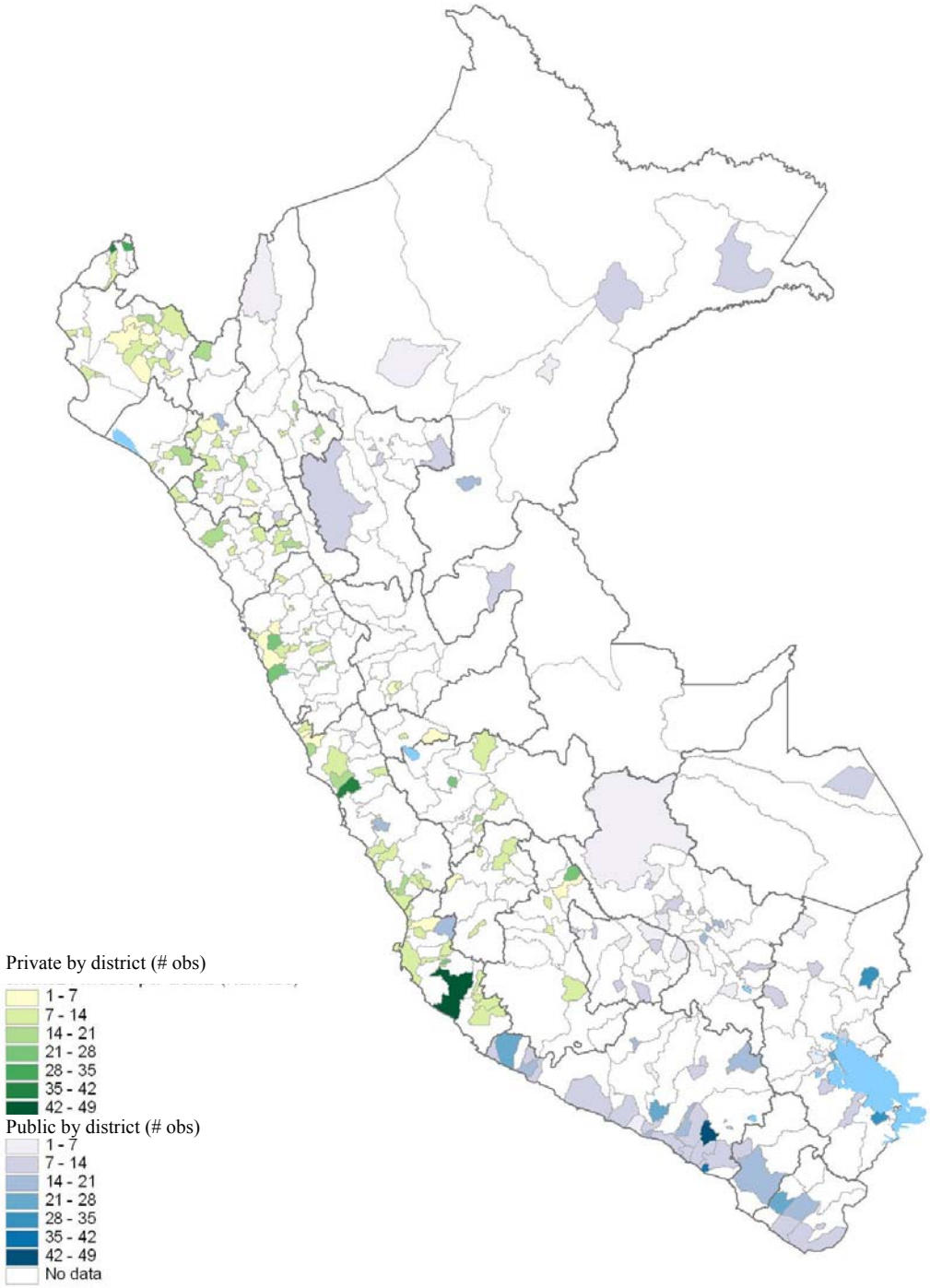
Table 9 shows the means of the main variables included in the database. As can be seen, most households without access to electricity are worse off than households with access to electricity, either through private or public sources. Households without access to electricity are less educated, have more members, have less access to other infrastructures, work mainly in farm activities, and have significantly lower per capita income and expenditure.

Table 9.
Distribution of Sample by Electricity Company

COMPANY	OBS	DEPARTMENTS
PRIVATE COMPANIES		
ELECTRONORTE MEDIO (HIDRANDINA)	341	Ancash, Cajamarca, La Liberta
ELECTRO NOROESTE	266	Piura, tumbes
ELECTRO SUR MEDIO	264	Ayacucho, Huancavelica, Ica
ELECTROCENTRO	243	Pasco, Junin, Huanuco, Huancavelica, Ayacucho
ELECTRONORTE	204	Lambayeque, Cajamarca, Amazonas
EDELNOR	115	Lima
EDE CAÑETE	96	Lima
LUZ DEL SUR	65	Lima
SOCIEDAD MINERA COLQUIRRUMI	15	Cajamarca
CMTE ELECTRIFICACION CHUGUR	5	Cajamarca
TOTAL PRIVATE 1/	1614	
TOTAL PRIVATE 2/	500	
PUBLIC COMPANIES		
SEAL	400	Arequipa
ELECTRO SUR ESTE	249	Madre de Dios, Cusco, Apurimac
ELECTRO PUNO	171	Puno
ELECTROSUR	117	Moquegua, Tacna
MUNICIPALITIES, LOCAL GOVERNMENTS, AND OTHERS	90	Various
ELECTRO ORIENTE	86	Loreto
ADINELSA	58	Lima, Ica
AUTODEMA	15	Arequipa
ELECTRO SAN GABAN	15	Puno
ELECTRO SHITARIYACU	14	San Martin
ELECTRO UCAYALI	11	Ucayali
TOTAL PUBLIC 1/	1226	1226 2340
TOTAL PUBLIC 2/	2340	

Source: National Survey of Rural Energy Demand.
The top for companies are the ones that correspond to the DISTRILUZ group.
1/ Considering DISTRILUZ as private.
2/ Considering DISTRILUZ as public.

Map 2. Map of Public and Private Operators by Location



Source: National Survey of Rural Energy Demand.

As seen in Table 10, a comparison of households with private access versus public access to electricity also shows significant differences, although in this case the differences are smaller and the direction is not clear (they are not consistently better off in one case or the other). For example, households with private access have a statistically significant higher number of members, the household head is older, there are more female household heads, they are less likely to be indigenous, they work fewer hours, and they concentrate more on non-farm activities. Therefore, it is necessary to make these two groups more comparable in order to analyze the potential impacts of private versus public provision of electricity. The following section details the methodology developed to make the groups comparable. Then, Section 5 presents the main differences with regard to some key dependent variables, such as performance of provision of electricity at the household level and the indirect impacts of better or worse performance on total hours of work and on allocation of working hours between farm and non-farm activities.

Table 10.
Summary Statistics of Main Variables under Study at the Household Level

	Without electricity (1)	With electricity		Diff is significant?		
		Public (2)	Private (3)	(1) & (2)	(1) & (3)	(2) & (3)
Household characteristics						
Age of household head	48.08	48.91	50.91		***	***
Years of education of HH head	5.00	7.07	6.97	***	***	
Female head of household	0.13	0.14	0.18		***	***
Indigenous HH head	0.32	0.45	0.19	***	***	***
Household size (members)	4.49	4.19	4.36	***	*	**
Proportion 0-5 y.o.	0.12	0.09	0.08	***	***	
Proportion 6-13 y.o.	0.19	0.18	0.18	*	**	
Proportion 14-60 y.o.	0.54	0.59	0.58	***	***	
Proportion 60 yrs or older	0.15	0.14	0.16			*
Household with pipeline water a/.	0.17	0.54	0.59	***	***	***
Other sources of water access a/.	0.23	0.16	0.13	***	***	**
Water from river, lake, etc. a/.	0.27	0.19	0.20	***	***	
Town characteristics						
Population (in thousands)	350.69	1228.41	1336.68	***	***	**
Public phone in town a/.	0.09	0.54	0.46	***	***	***
Secondary school in town a/.	0.13	0.56	0.52	***	***	**
Paved road in town a/.	0.26	0.63	0.61	***	***	
Town in coast a/.	0.35	0.39	0.59	**	***	***
Town in highlands a/.	0.46	0.47	0.36		***	***
Town in jungle a/.	0.18	0.14	0.05	***	***	***
Time allocation and welfare						
Hours of work - HH	12.18	12.54	10.90	*	***	***
Hours of work - HH (incl chores)	19.17	19.16	17.27		***	***
Prop of non-ag hours of work - HH	0.23	0.39	0.49	***	***	***
Prop of non-ag hours of work - HH (incl chores)	0.14	0.25	0.29	***	***	***
Hours of leisure (TV and radio)	3.24	4.17	4.42	***	***	**
Hours of leisure (TV, radio, socializing, and others)	6.98	7.71	9.16	***	***	***
Proportion of non-ag income	0.31	0.33	0.40		***	***
Per capita expenditure	136.47	198.24	217.25	***	***	***
Energy						
Number of sources of electricity	4.00	3.09	2.83	**	***	***
Exp in electricity (% of exp in energy)	N/A	0.47	0.48	N/A	N/A	
Exp in electricity (% of total exp)	N/A	0.05	0.05	N/A	N/A	
Price per Kw	N/A	1.08	1.00	N/A	N/A	
Number of monthly failures (30+ min)	N/A	1.32	1.30	N/A	N/A	
Often dimming in elect service a/.	N/A	0.13	0.11	N/A	N/A	**
Monthly hours of blackouts c/.	N/A	5.62	4.59	N/A	N/A	**

4. Statistical and Econometric Methodology

This section compares differences in the set of dependent variables between households in privatized areas and a comparison group consisting of a sample of similar households in communities (*centros poblados*) where privatization has not yet taken place, as shown in Map 2. To construct the required comparison group, a two-step matching process was followed and is detailed in Figure 2.

The process first consists of a non-parametric town matching and a household matching based on propensities scores with the distribution of bootstrapped means of matched treatments and controls. With respect to town matching, we estimate the control town and treatment town pairs non-parametrically using cell means based on access to public telephone, type of road, secondary school in town, quintiles of population, and region (coast, sierra, or jungle). The resulting matching yielded a distribution of treated and control towns that were approximately symmetrically distributed.

Second, household matching is based on propensity scores of households within each control and treatment town group. The framework serving as a guideline for the empirical analysis is the Roy-Rubin model (Roy, 1951; Rubin, 1974). Inference on the impact of a treatment (privatization in our specific case) on the outcome of an individual involves speculation about how this individual would have responded had he or she not received the treatment. Therefore, the objective will be to capture what happened to a household in a privatized area versus what happened to a household in a non-privatized area.

We define a binary assignment indicator, *D*, indicating whether a household unit actually was affected by the program (*D*=1, meaning the household is located in a community where electricity is provided by a private firm) or not (*D*=0) (Hujer and Wellner, 2000; Lechner, 2000). The treatment effect of each household is then defined as the difference between its potential outcomes:

$$\Delta = Y^T - Y^C \qquad (1)$$

where *Y* will be the income (welfare effect) of the household and the supra indices refer to the treatment group (*T*) and the control group (*C*) where the treatment is an area where the electric company (distribution) was privatized.

The fundamental problem of evaluating this household treatment effect arises because the observed outcome for each household unit is given by:

$$Y = D \cdot Y^T + (1-D) \cdot Y^C \qquad (2)$$

Unfortunately we can never observe Y^T and Y^C for the same household unit simultaneously. The unobservable component in (2) is called the counterfactual outcome, so that for households that participated in the measure (D=1), Y^C is the counterfactual outcome, and for those that did not, it is Y^T. Therefore, there will never be an opportunity to estimate households' gains with confidence. As a result, we have to concentrate on the population average of gains from treatment: the average treatment effect on the treated:

$$E[\Delta \backslash D=1] = E(Y^T \setminus D=1) - E(Y^C \setminus D=1) \qquad (3)$$

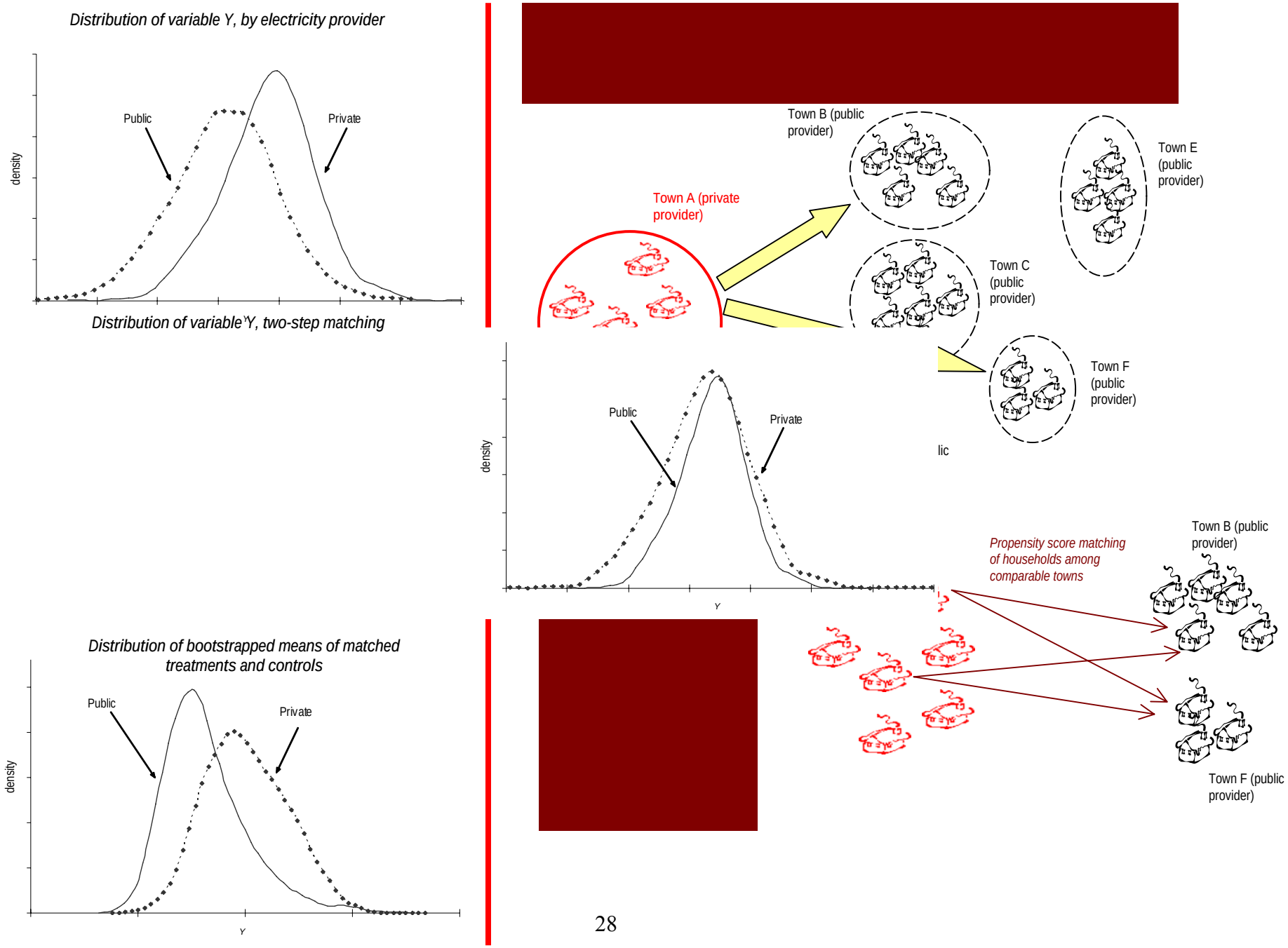
As Hujer and Wellner (2000) note, this parameter provides an answer to the following question: "What is the expected or mean outcome gain for individuals who received treatment as opposed to a hypothetical situation where they do not receive it?" This question focuses directly on actual participating units, so that it determines the realized gross gain from the program and can be compared with its costs. This will help decide whether the program is a success or not (Heckman, Ichimura and Todd, 1997 and 1998; Heckman, LaLonde and Smith, 1999).

The second term on the right side of Equation (3) is unobservable since it describes the hypothetical outcome without treatment for those units that received treatment. If the condition:

$$E(Y^C \setminus D=1) = E(Y^C \backslash D=0) \qquad (4)$$

holds, we can use non-participants as an adequate control group. This identifying assumption is likely to hold only in social experiments, where the key concept is randomized assignment of households units into treatment and control groups. In non-experimental data, as in this study, Equation (4) will normally not hold. The use of non-participants as a control group will therefore lead to a selection bias. Heckman and Hotz (1989) point out that selection might occur on observables and unobservables.

Figure 2.
Two-Step Matching



We will try an estimation approach that estimates the unobserved counterfactual term using the observed outcome information obtained from the non-participants and taking into account selection on observables as well as selection on unobservables (see Hujer and Caliendo, 2000, for a detailed description).

To develop the control group, we use the propensity score matching approach. The basic idea underlying the matching approach is to search within a large group of non-participants in the matched towns to find those individual units that remain similar to the participants in all relevant pre-treatment characteristics. A variable summarizing all these relevant characteristics is estimated as the probability of receiving based on a probit model.[10] Households in the treatment group are matched to relevant controls as a function of differences in their propensity scores. From among the different approaches as to how to match households in both groups (i.e., one-to-one, radial, "k" nearest neighbors, local linear regression, etc.), we opted for kernel matching with a quadratic function (Epanechnikov). Under the latter methodology, each household of the treatment group is matched to a weighted average of all available controls. For each treatment, a set of weights is estimated for every control as a function of the difference between its propensity score and that of the control. Once a suitable counterfactual for every treatment observation has been found, the differences in the outcomes between well-selected and adequate control group and the participants can then be attributed to the program.

Finally, we use bootstrapping to recover the empirical distribution of the treatments and the controls. The significance level of the differences is then computed after 10,000 iterations following Davidson and MacKinnon (1999).

5. Empirical Results

Theoretically, propensity score matching should be able to balance characteristics not related to treatment, but it is prone to affecting the outcome variables between treatment and control groups. Thus, if all the relevant characteristics remain the same, with the only difference being in the treatment, it can be inferred that discrepancies in the outcome variables between both groups can be attributed to the program under assessment.

Our results suggest that our proposed two-step propensity score matching procedure performs better, finding more rigorous counterfactuals for households with private provision of

[10] Several procedures for matching the propensity score can be used. A good review can be found in Heckman et al. (1998).

electricity. To test this improvement, we analyzed how well different matching methods balance the differences in a set of observable characteristics between households with public and private provision of electricity. To simplify, we performed a one-to-one matching procedure of households in the treatment and control groups with three alternative procedures: (i) traditional propensity score matching considering household characteristics, (ii) traditional propensity score matching considering household and town characteristics in a single probit equation, and (iii) our proposed two-step estimator. This allowed us to observe not only the differences in the outcome variables (as in the case of the kernel matching), but also the differences in other observable characteristics of each treatment and its selected control household. Our results are presented in Appendix C. Our method provides better balancing between both groups and, overall, achieves satisfactory comparability.

The transfer from the public to the private sector (Vickers and Yarrow, 1988) necessarily implies a change in the relationships between those responsible for the firm's decisions and the beneficiaries of the profit flows (the social view and the agency view). In theory, the transfer of property rights leads to a different structure of management incentives, causing changes in managerial behavior, company performance, and quality of service in terms of access and use. In this paper we concentrate on changes in the quality of service and on their respective impacts on a household's welfare. Specifically, the main objective of this paper is to assess the two main effects of the provision of electricity through a private provider: first, the effects on electric service quality, and second, whether this improvement in quality results in an improvement in a household's welfare through its effects on either changes in total hours of work or on time allocation between farm and non-farm activities.

5.1 Changes in the Quality of Electricity Service

It is expected that a change in private provision, with different management structure incentives, should significantly improve the quality of the service. Specifically, the traditional literature normally mentions that privatization will have a significant impact on investment, access, quality of service, and a realignment of tariffs. In the Peruvian case, as we have previously shown, there was a significant improvement in investment as a result of the privatization. Similarly, the coefficient of electrification increased significantly during the past decade. For example, currently 100 percent of Edelnor customers (83 percent of whom belong to the poorer segments of Lima's inhabitants) have electricity. Edelnor's investments have added to the network 225,000

customers in approximately 500 communities. Similarly, a significant realignment of tariffs was expected, so that they would reflect real costs, resulting in losses in the consumer surplus of households. However, as mentioned before, in 2001, a "social tariff" for electricity consumption was established (FOSE—"Fondo de Compensación Social Eléctrica").

Finally, with respect to the quality of service, it is expected that consumers will face fewer service failures (less dimming in electric services, fewer hours of blackouts, and a lower number of failures), have more hours of electricity, use fewer sources of energy, and increase their consumption of electricity.

Table 11 presents the results of the electricity performance indicators at the household level after the two-step matching procedure. As expected, households that use distribution from privatized providers have better quality of electricity provision. Specifically, households report less dimming, a smaller number of monthly failures, and lower monthly hours of blackouts. This implies that they have a better quality of provision and a subsequent reduction in costs. Similarly, households with private provision have significantly higher expenditures on electricity, both as share of their total expenditure and also as share of their expenditure on energy sources. This result, together with the fact that prices are lower, implies that there is a clear increase in the amount of electricity consumption by these households.

Additionally, and as expected, there is a significant reduction in the number of sources of energy used by households linked to private providers. As mentioned in Appendix B, households can access energy from 14 possible sources,[11] but given improvements in the quality and hours of electricity provision, it seems they reduce their overall sources of energy from 3.169 to 2.84.

[11] The options are (1) electricity, (2) kerosene, (3) candles, (4) dry cell batteries, (5) car batteries, (6) liquefied petroleum gas, (7) solar home system, (8) firewood, (9) animal dung, (10) crop residues, (11) electric generator set, (12) charcoal, (13) coal, and (14) others.

Table 11. Matching Results on Performance Indicators

	Mean		ATT	S.E.	[95% Conf Interval]		
	Treat	Control					
Exp in electricity (% of exp in energy)	0.48	0.46	0.02	0.02	-0.01	0.05	
Exp in electricity (% of total exp)	0.05	0.05	0.00	0.00	-0.01	0.01	
Number of sources of electricity	2.83	3.19	-0.36	0.07	-0.49	-0.22	**
Price per Kw	1.04	1.14	-0.10	0.07	-0.36	-0.05	**
Number of monthly failures (30+ min)	1.41	1.53	-0.12	0.16	-0.38	0.25	
Often dimming in elect dervice	0.12	0.16	-0.04	0.01	-0.10	-0.01	**
Monthly hours of blackouts [a/.]	4.72	5.66	-0.94	0.64	-2.24	0.24	

a/. The two-stage PS matching difference was significant at 10 percent.
** denotes significance at a 95 percent level of confidence
Note: Standard errors are based on 10,000 iterations of the two-step matching procedure. See Appendix B for a description of the variables.

The next question to ask is whether these improvements in the provision of electric service have an impact on a household's welfare, or what we have called potential indirect impacts.

5.2 Impacts of Better Quality of Electric Service on Hours of Work and on Time Allocation for Farm and Non-Farm activities

The aggregate level links between poverty and rural infrastructure have been studied by several authors, but among the most important of these works are Lipton and Ravallion (1995), Jiménez (1995), and Van de Walle (1996), in addition to those cited above.[12]

In order to further analyze the effects of public infrastructure, and specifically the effects of the improvement of the quality of electricity due to the presence of a private distributor, it is necessary to distinguish between direct and indirect effects. The former occur when an increase in access to electricity is accompanied by an increase in production, shifting the production frontier and marginal cost curve, and also increasing the rate of return for private investment in rural activities. The latter take place when access to more or higher quality electricity permits a

[12] For a specific infrastructure impact case (like the role of rural roads, telephones, or access to electricity on poverty alleviation) the literature is very broad and includes works such as Howe and Richards (1984), Binswanger, Khandker, and Rosenzweig (1993), Jacoby (1998), and Lebo and Schelling (2001), among others. Recently, Renkow, Hallstrom, and Karanja. (2003) estimate the fixed transaction costs (those not dependent on commercialized volume) that impede access to product markets by subsistence farmers in Kenya. These authors estimate that high transaction costs are equivalent to a value-added tax of approximately 15 percent, illustrating the opportunities to raise producer welfare with effective infrastructure investments. Smith et al. (2001) show that the rehabilitation of roads in Uganda increases labor opportunities in the service sector.

reduction in the transaction costs that small producers face when they integrate into the supply and factor markets. These lower transaction costs change the structure of relative prices significantly for the producer, stimulating changes as transitions occur in the allocation of the labor force between agricultural and non-agricultural uses. The latter effects are what we are trying to measure in this subsection.

There are three possible channels through which these indirect impacts on income may be affected by access to infrastructure and, in our specific case, to better quality of electricity provision. On the one hand, there is the impact of changes on the proportion of working hours allocated to different activities. Specifically, we analyze shifts in labor devoted to agricultural and non-agricultural activities. Our hypothesis is that access to better quality of electricity leads to greater opportunities for non-farm work activities. On the other hand, the second channel captures the effect of changes in the household's total working hours as a result of longer hours of access to electricity. Finally, there is scope for increases in rural households' market efficiency through increases in their purchasing power. Along these lines, the third channel captures changes based on returns to labor (that is, hourly wages) allocated to agricultural and non-agricultural activities. Specifically in the case of agricultural activities, this will be directly related to prices of their products. In this study we will concentrate on the first two effects given that their relationship to better quality and hours of electricity is clearer.

Table 12 provides results for labor mobility and the allocation of labor between farm and non-farm activities. Better quality of electricity has a significant and positive effect on labor mobility to non-farm activities. Specifically, there is an increase in non-farm activities in the three indicators presented. Households with private provision of electricity allocate around 10 percent more of their working time to non-farm activities. Specifically, without including chores, they expend 50 percent of their time on average on non-farm activities while households with public access expend an average of 40 percent of their time on non-farm activities. This proportion increases to 52 percent when we conduct an analysis at the individual level rather than at the household level. The rural non-farm sector has developed as a major source of employment, and it seems that there is a positive association between this kind of development and a better quality and duration of the provision of electricity. The non-farm activities that have developed so far, however, appear to be mainly in the tertiary sector, probably as a result of rural

electrification. The secondary sector remains insignificant as a source of rural employment and income.

Table 12.
Indirect Impacts of Better Access and Better Quality of Electricity

	Mean		ATT	S.E.	[95% Conf Interval]		
	Treat	Control					
Hours of work - HH	10.66	12.34	-1.68	0.35	-2.45	-1.09	**
Hours of work - HH (incl chores)	17.00	19.18	-2.18	0.31	-2.94	-1.75	**
Prop of non-ag hours of work - HH	0.50	0.40	0.10	0.03	0.05	0.16	**
Prop of non-ag hours of work - HH (incl chores)	0.29	0.25	0.04	0.02	0.01	0.08	**
Hours of work - indiv (incl chores)	5.34	6.19	-0.86	0.18	-1.25	-0.53	**
Hours of work - indiv	8.50	9.68	-1.18	0.13	-1.55	-1.03	**
Prop of non-ag hours of work - indiv	0.52	0.43	0.09	0.02	0.04	0.13	**
Prop of non-ag hours of work - indiv (incl chores)	0.28	0.25	0.03	0.02	0.00	0.06	

** Denotes significance at a 95 percent level of confidence
Note: Standard errors are based on 10,000 iterations of the three-step matching procedure. See Appendix B for a description of the variables.

With respect to the total working hours, propensity score matching was used to formally assess the impact of private provision of electricity on total household hours worked per average day, as was the case with the share of farm and non-farm activities. The results show that households with access to electricity from private providers work an average of 1.7 hours less and per capita around 1.18 hours less. A possible explanation is that men and women allocate their time to a variety of economic and non-economic activities with important implications for their income, health, leisure, and overall livelihood and well-being. As a result, better access to electricity and non-farm activities could allow them to increase their efficiency, reduce their total work burden, increase their leisure time, or earn more income using the same number of working hours.

When we examine in detail the time allocation of the household head and spouse between treatment and control households (see Table 13), differences in time allocation are concentrated in three main activities. First, as previously mentioned, there is a significant increase in time allocated to non-farm activities or more time allocated by the control on farm activities (4.34 percent); secondly, the treatment group spends more time on handcrafts and shop tending (1.62 percent) and other leisure activities (2.87 percent). This result is consistent with communities

with more hours of electricity and with better quality of service, which allows them to assign part of their time to non-farm-related activities and to have better choices in leisure activities.

Table 13.
Differences in Time Allocation between Treatment and Control Households [a/.]
(Head of household + spouse [b/.])

	Hours			Distribution		
	Control	Treatment		Control	Treatment	Difference
Sleeping	16.13	16.25		33.61%	33.85%	0.24%
Bathing / grooming	0.90	1.13	***	1.87%	2.36%	0.49%
Cooking	2.96	3.11		6.16%	6.48%	0.32%
Farming, gardening, animal husbandry, fishing	7.12	5.04	***	14.83%	10.50%	-4.34%
Income earning act. such as handicrafts, tending shop, etc	4.43	5.21	**	9.22%	10.85%	1.62%
Eating	2.84	2.95		5.91%	6.15%	0.24%
Processing food	0.27	0.22		0.57%	0.45%	-0.12%
Water fetching and fuel collection	0.56	0.52		1.17%	1.09%	-0.08%
Laundry, house cleaning	2.31	2.19		4.82%	4.57%	-0.25%
Repairing clothes, basket equipment, tools, etc	0.65	0.45	***	1.36%	0.94%	-0.42%
Religious practices (praying, reading bible, etc)	0.37	0.34		0.77%	0.71%	-0.06%
Reading, studying	0.43	0.53		0.90%	1.10%	0.20%
Watching TV, listening to radio, resting	4.74	4.58		9.88%	9.54%	-0.34%
Visiting neighbors, socializing	1.57	1.85	*	3.28%	3.85%	0.57%
Other leisure activities	1.52	2.90	***	3.16%	6.03%	2.87%
Shopping	1.19	0.70	***	2.48%	1.46%	-1.02%
Other	0.00	0.04		0.00%	0.09%	0.09%
Total	48.00	48.00		100.00%	100.00%	0.00%

Notes:
a/. Nearest neighbor (caliper=0.01) two-step propensity score matching.
b/. Sample has been limited to households with available information for both head of household and spouse.

Finally, Table 14 presents some global measures of welfare. Consistent with the previous results, per capita expenditure is not statistically different between both types of households. This could be because major income changes occur as a result of having or not having access, and in our specific analysis both groups of households already have access to electricity. Moreover, households with better provision of electricity work fewer total hours because they can compensate their income with activities in the non-farm sector, which pay higher salaries. Therefore, our results seem to indicate that the quality of electricity matters in increasing the availability of non-farm activities and therefore the distribution of working hours between farm, non-farm, and leisure activities. This result is clear when we analyze the proportion of non-farm income. Non-farm income accounts for 41 percent of the total income of households with private provision of electricity and 32 percent of the income of households with public provision. In

addition, households with private provision spent around 1.5 hours more on leisure activities. In summary, better quality of electricity implies a more efficient allocation of rural households' time, which allows them to have more time for recreation.

Table 14.
Indirect Impacts of Better Access and Better Quality of Electricity on Total Welfare

	Mean		ATT	S.E.	[95% Conf Interval]		
	Treat	Control					
Per capita expenditure	219.25	228.10	-8.85	8.75	-31.11	3.70	
Proportion of non-ag income	0.41	0.32	0.09	0.03	0.02	0.14	**
Hours of leisure (TV and radio)	4.55	4.60	-0.05	0.17	-0.42	0.26	
Hours of leisure (TV, radio, socializing, and others)	9.41	7.86	1.54	0.29	0.97	2.10	**

** Denotes significance at a 95 percent level of confidence
Note: Standard errors are based on 10,000 iterations of the two-step matching procedure. See Appendix B for a description of the variables.

6. Conclusions

The passage of the Law of Electric Concessions (DL 25844) in November 1992 set the stage for a comprehensive reform of Peru's electric sector. Reinforcing the subsidiary role of the state, the new operating and institutional frameworks sought to maximize efficiency and enhance competition in all electricity activities. Those frameworks, while promoting the system's interconnectivity, provided for a vertical unbundling of the sector that segmented the power generation, transmission, and distribution activities, and defined free competition and regulated markets.

Of the three large segments—generation, transmission, and distribution—the generation segment operates under perfect competition and can be conducted by private and public enterprises. Within the transmission segment, the main network system is operated by a private operator under a 30-year concession scheme with the government. Other secondary transmission lines are also mostly private but the government participates with some investments.

The distribution segment consists of a mixture of public and private providers and is mostly regulated, given its characteristics as a natural monopoly. Currently, based on the number of clients served, electricity distribution is 47 percent private. The presence of private and public

providers offered a unique opportunity to evaluate the impact of public versus private provision within the same country.

Our results can be summarized as follows: first, there is a significant improvement in the quality of the provision of electricity when distribution firms are managed by the private sector. This result is consistent with solid work that supports the proposition that privatization improves the operating and financial performance of firms (Galal et al., 1994; La Porta and López-de-Silanes, 1999; and the studies summarized in D'Souza and Megginson, 1999)

Secondly, improvements in the quality and supply of electricity provision yield some efficiency gains in terms of the time allocation of the working labor force that can be directly linked to the use of electricity. Rural households under private provision of electricity had more opportunities to work in non-farm activities, and as a result, the share of non-farm activities increased, indicating both a substitution effect and a potential price effect. The substitution effect implies a reduction of hours spent on farm activities in favor of non-farm activities and the price effect implies that households will receive higher salaries and therefore will need to work fewer hours in total. As a result, the increase in time spent on non-farm activities was accompanied by a reduction of hours spent on farm activities and an increase in the hours spent on leisure.

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Appendix A

Table A.1.
Private Investments

(thousands of US$)

Private Companies	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Electrical partnership Villacuri S.A.C (Coelvisa)						281	856	36,591	491	180	568
Edelnor	9,021	23,889	53,642	56,848	30,900	41,037	36,000	40,011	30,160	22,213	18,722
Electro Pangoa							24				
Electro sur medio	1,234*	5,788*	10,318*	3,330	4,169	2,487	3,356	1,847	935	586	236
Ede Cañete							222	239	509	458	1,588
Electro Paramonga						17	13	2			
Electro Tocache							160		85		
Electro Utcubamba			12	9	9	37	133				
Luz del sur	19,854	34,628	44,516	39,342	41,203	28,805	26,900	29,419	32,841	24,802	30,507
Public Companies											
Electro centro	7,337	11,849	17,145	6,522	1,285**	1,190**	20,337**	2,232**			
Electro noroeste	10,700	10,705	12,108	19,868	11,467**	11,192**	4,478**	1,605**			
Electro norte medio	4,819	16,692	4,796	1,239	1,196**	n.a.	28,761**	4,799**			
Electro norte	8,134	2,493	10,362	4,692	4,179**	2,379**	1,878**	1,970**			
Electro Oriente	1,205	677	9,952	5,902	9,298	8,135	2,339	7,706	2,338		851
Electro Puno							1,161	16	482	1,208	204
Electro Sur Este	6,264	48,943	17,612	22,375	26,387	16,793	2,314	2,541	2,628	2,700	2,588
Electro Ucayali						1,122	1,363	559	337	93	
Electro sur	1,211	998	3,856	2,857	1,957	1,093	1,293	999	1,537	1,279	1,150
Chavimochic							351				
Electrical services Rioja							5		1		28
SEAL	3,621	6,737	8,959	8,477	44,526	6,931	7,262	3,845	5,549	4,033	4,131
Total	73,400	163,399	193,278	171,461	176,576	121,499	139,206	134,381	77,893	57,552	60,573
Private Investments	28,875	58,517	98,170	99,529	90,239	87,425	123,118	118,715	65,021	48,239	21,114
Percentage of private investments	39.3%	35.8%	50.8%	58.0%	51.1%	72.0%	88.4%	88.3%	83.5%	83.8%	34.9%

*Property of the state / **Private property.
Source: MEM

Appendix B

Description of Variables

Variable	Description
Welfare	
Household per capita expenditure	Includes expenditures on energy sources (electricity, kerosene, candles, dry cell batteries, car batteries, liquefied petroleum gas, solar home system, firewood, animal dung, crop residues, electric generator set, charcoal, coal and others); food; expenditures for water, telephone and transportation; home maintenance and repair; products of personal hygiene; recreation activities; health care, education, transfer expenditures, clothing and shoes; and furniture and cooking utensils. Variable estimated in Metropolitan Lima Peruvian soles of June 2005.
Total agricultural income	Includes income from self-employment in agriculture, livestock and fisheries; and salaried work. Salaried work was considered agricultural when the individual reported working in two-digit ISIC codes 1, 2 and 5. Around 15 percent of individuals declaring salaried income did not report the activity they were working in. To avoid misrepresentation due to missing data, households with any member declaring salaried income but lacking information on economic activity were not considered in the estimations.
Total non-agricultural income	Includes income from business and salaried work. Salaried work was considered agricultural when the individual reported working in two-digit ISIC codes 1, 2 and 5. Around 15 percent of individuals declaring salaried income did not report the activity they were working in. To avoid misrepresentation due to missing data, households with any member declaring salaried income but lacking information on economic activity were not considered in the estimations.
Proportion of non-agricultural income	Ratio of total non-agricultural income to non-agricultural income plus agricultural income.
Daily hours of work (1)	Sum of daily hours of work in agricultural and non-agricultural activities of head of household and spouse. Variable is only calculated for married households (i.e. with information for BOTH head and spouse). Hours of agricultural work include farming, gardening, animal grazing, fishing, etc. Non-agricultural work includes employment in shop, production of handicrafts and others; processing food; repairing clothes, basket, machineries, equipment, etc.
Daily hours of work (2)	Sum of daily hours of work in household chores, agricultural activities and non-agricultural activities of head of household and spouse. Variable is only calculated for married households (i.e. with information for BOTH head and spouse). Household chores include: preparing meals; fetching water; washing clothes; house cleaning; and shopping. Agricultural work includes farming, gardening, animal grazing, fishing, etc. Non-agricultural work includes employment in shop, production of handicrafts and others; processing food; repairing clothes, basket, machineries, equipment, etc.
% of non-agricultural hours of work (1)	Daily hours of non-agricultural work as a proportion of daily hours of work (agricultural and non-agricultural hours of work). Variable is only calculated for married households (i.e., with information for BOTH head and spouse).

% of non-agricultural hours of work (2)	Daily hours of non-agricultural work as a proportion of daily hours of work (agricultural hours of work, non-agricultural hours of work and household chores). Variable is only calculated for married households (i.e., with information for BOTH head and spouse).
Hours of leisure 1	Hours spent by households resting, watching TV, or listening to the radio. Variable is only calculated for married households (i.e., with information for BOTH head and spouse).
Hours of leisure 2	Hours spent by households resting, watching TV, listening to the radio, visiting neighbors, socializing, entertaining guests, and engaging in other leisure activities. Variable is only calculated for married households (i.e., with information for BOTH head and spouse).
Electricity	
Expenditure in electricity as % of total expenditure	Expenditure in electricity as a percentage of total household expenditure.
Expenditure in electricity as % of total expenditure in energy	Energy sources include: electricity; kerosene; candles; dry cell batteries; car batteries; liquefied petroleum gas; solar home system; firewood; animal dung and crop residues (hours of dung and residue collection were valued using urban/rural hourly wages for each department, reported in ENAHO 2004), electric generator set, charcoal, coal, and others.
Sources of energy	Number of sources of energy used by household from among 14options: (1) electricity, (2) kerosene, (3) candles, (4) dry cell batteries, (5) car batteries, (6) liquefied petroleum gas, (7) solar home system, (8) firewood, (9) animal dung, (10) crop residues, (11) electric generator set, (12) charcoal, (13) coal, and (14) others.
Price	Soles/kw paid by household. Survey provides three options for reporting expenditure in electricity: Households paying a flat rate or by number of electrical appliances/light bulbs report their constant monthly payment. In the case of households paying per kw consumed, pollster requests their last three electricity bills. If respondents cannot show these bills, pollster asks for the approximate average payment of electricity during the 12 months previous to the survey. Price can only be estimated when respondents show their bills (which include their payment and the number of Kw consumed).
Failures	Number of 30-minutes-or-more failures during the month previous to the survey.
Hours without electricity	Number of hours without electricity due to cuts or blackouts during the month previous to the survey.
Dimming in electricity service	Proportion of households reporting frequent dimming in electricity service.
Characteristics of town	
Access to phone	Information taken from the INEI's Pre census 1999-2000. Public telephone available in town.
Type of road	Information taken from the INEI's Pre census 1999-2000. Main type of road communicating the town with the capital of district. Roads are classified in two categories: (1) *caminos carrozables*, *caminos de* herradura, *trocha*, rivers, and others; and (2) paved and *afirmada* roads
Secondary school	Information taken from the INEI's Pre census 1999-2000. Secondary school available in town.
Quintile of population	Towns in the sample were classified in quintiles according to population reported in INEI's Pre census 1999-2000.
Region	Coast, Sierra, and Jungle.

Characteristics of household	
Household size	Number of members of household
Composition	Proportion of members 0-6, 7-14, 15-60, and 60 years or older.
Ethnicity	Self-reported ethnicity of household head among seven options: (1) native *quechua*, (2) native *aymara*, (3) native *amazonico*, (4) African-Peruvian; (5) Asian origin; (6) Caucasian; (7) *Mestizo* (cross breed)
Sex of head of household	Male or female head of household
Education of head of household	Years of education of head of household
Water supply in dwelling	Three possibilities for water supply used for drinking and cooking: (1) supply through public network; (2) well, pylon, or others; (3) river, springs, lakes, etc.

Appendix C

Balance of Variables in Common Support in Different Methods of Propensity Score Matching a/.

(Nearest neighbor matching, caliper = 0.05)

	Unmatched sample			PS Match - household b/.			PS Match - household + town c/.			Two stage PS Match d/.		
	Control	Treatment		Control	Treatment		Control	Treatment		Control	Treatment	
Household characteristics												
Household size (members)	4.19	4.36	**	4.33	4.33		4.45	4.31	*	4.23	4.31	
Porportion 6-13 y.o.	0.18	0.18		0.17	0.18		0.18	0.18		0.17	0.17	
Porportion 14-60 y.o.	0.59	0.58		0.57	0.58		0.57	0.58		0.59	0.58	
Porportion 60 yrs or older	0.14	0.16	*	0.17	0.16		0.16	0.16		0.17	0.16	
Indigenous HH head	0.45	0.19	***	0.18	0.19	*	0.20	0.19		0.18	0.18	
Household with pipeline water	0.54	0.59	***	0.58	0.59		0.60	0.59		0.64	0.67	*
Other sources of water access	0.16	0.13	**	0.15	0.13		0.11	0.14	**	0.14	0.11	**
Water from river, lake, etc	0.19	0.20		0.20	0.20		0.21	0.20		0.17	0.15	
Years of education of HH head	7.07	6.97		6.94	6.99		6.98	7.00		7.11	7.35	
Age of household head	48.91	50.91	***	50.65	50.82		51.03	50.68		51.69	51.19	
Female head of household	0.14	0.18	***	0.17	0.18		0.16	0.18		0.15	0.16	
Town characteristics												
Paved road in town	0.63	0.61		0.68	0.61	***	0.67	0.62	***			e/.
Public phone in town	0.54	0.46	***	0.64	0.46	***	0.49	0.47				e/.
Population (in thousands)	1.23	1.34	**	1.42	1.33	*	1.18	1.35	***			e/.
Secondary school in town	0.56	0.52	**	0.64	0.52	***	0.52	0.52				e/.
Town in coast	0.39	0.59	***	0.51	0.59	***	0.61	0.59				e/.
Town in highlands	0.47	0.36	***	0.32	0.36	***	0.34	0.37				e/.
Town in jungle	0.14	0.05	***	0.17	0.05	***	0.05	0.05				e/.
Obs	1188	1483		1476	1476		1437	1437		906	906	

a/. For detailed definition of variables, please see Appendix B.
b/. Probit regression includes household variables.
c/. Probit regression includes household and town variables.
d/.First stage: towns with same characteristics (roads, public phone, quintile of population, secondary school, and region).
Second stage: propensity score matching within households in comparable towns.
e/. By definition, town variables are the same in the two-step matching.

Appendix D

Summary Statistics of Performance, Quality of Service and Welfare Indicators (unmatched)

	Unmatched sample				
	Treatment		Control		Diff
	Mean	Obs	Mean	Obs	
Exp in electricity (% of exp in energy)	0.48	1473	0.47	1186	0.01
Exp in electricity (% of total exp)	0.05	1483	0.05	1188	0.00
Number of sources of electricity	2.83	1483	3.09	1188	-0.26 **
Price per Kw	1.00	499	1.08	293	-0.08
Number of monthly failures (30+ min)	1.30	1408	1.32	1073	-0.02
Often dimming in elect service	0.11	1483	0.13	1188	-0.03 **
Monthly hours of blackouts	4.59	1312	5.62	1028	-1.03 **
Hours of work - HH	10.90	1061	12.54	876	-1.64 **
Hours of work - HH (incl chores)	17.27	1061	19.16	876	-1.89 **
Prop of non-ag hours of work - HH	0.49	1012	0.39	859	0.09 **
Prop of non-ag hours of work - HH (incl chores)	0.29	1057	0.25	876	0.04 **
Hours of work - indiv (incl chores)	5.45	2168	6.26	1799	-0.81 **
Hours of work - indiv	8.63	2168	9.59	1799	-0.96 **
Prop of non-ag hours of work - indiv	0.50	1727	0.42	1605	0.08 **
Prop of non-ag hours of work - indiv (incl chores)	0.27	2097	0.25	1775	0.02 **
Per capita expenditure	217.25	1447	198.24	1147	19.01 **
Proportion of non-ag income	0.40	906	0.33	823	0.07 **
Hours of leisure (TV and radio)	4.42	876	4.17	1061	0.24 **
Hours of leisure (TV, radio, socializing, and others)	9.16	876	7.71	1061	1.46 **

a/. The table presents the unmatched means of interest variables in Tables 11, 12 and 13.
** denotes significance at a 95% level of confidence.
For variable definitions, please see Appendix B.