

# **Regulation, Monitoring, and Ownership Influence the Quality of Service of Latin American Electric Distribution Utilities: A Doctoral Research Proposal**

by

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## **Abstract**

The decline in the quality of service of electric distribution utilities in Latin America is a topic requiring investigation because of its effect on the sustainability of privatization. The quality of service could be a hidden cost of privatization because the policies of regulation have neglected the quality-of-service issue. The aim of this study will be to determine the influence of regulation, monitoring, and ownership on the quality of service of Latin American electric distribution utilities. A panel data technique will be appropriate for the analysis because of the need to incorporate cross-sectional and time-series data. The outcomes of this research may help regulators and decision makers to implement policies to improve the quality of service.

*Keywords:* Regulation, Monitoring, Ownership, Quality, Utility.

## **CHAPTER 1: INTRODUCTION**

In the 1990s, because of a severe electricity crisis, many Latin American countries decided to privatize state-owned electric companies. The aims of this decision included attracting foreign capital to invest in new-generation power plants, improving access to the service, improving the quality of the service, and cutting fiscal losses (Paliza, 1999). The focus of most evaluations of privatization has been operation and financial performance. However, increased efficiency and profitability may result at the expense of workers, customers, and other groups because of higher prices, reduced levels of employment, and low quality of service (Kessides, 2004; Shirley, 2004).

After a decade of honeymoon with the government, the private utilities and consumers raised concerns regarding the incompleteness of the goals of privatization. The concerns resulted in a debate on the fairness of the model and restarted the ideological debate of whether the state or the private sector should provide the electric service (Kikeri & Nellis, 2004; Millan, 2006). Latin Americans disagree or strongly disagree that the privatization of state companies has benefited their country (Panizza & Yañez, 2006). The diminishing quality of service is one of the main factors for rejecting privatization in Latin American countries (Shirley, 2004). Understanding why the quality of service is declining may aid the debate.

## Background of the Problem

In Latin America, researchers have been concentrating on cross-sectional studies for measuring productivity and performance, which influence the profitability of the utilities. The results of these studies show that the productivity and profitability of the private electric utilities have improved since the reform (privatization) through the important reduction of costs (Alva & Bonifaz, 2004; Estache & Rossi, 2004; Farsi & Filippini, 2004; Fisher, Gutierrez, & Serra, 2003; Rodríguez Pardina, Rossi, & Ruzzier, 1998; Rossi & Ruzzier, 2002; Rudnick & Zolezzi, 2001). Nonetheless, other researchers argued that even though utilities have improved efficiency, regulators have been unable to pass on the cost efficiency in terms of low prices to customers (Estache, Guasch, & Trujillo, 2003; Fisher et al., 2003).

Furthermore, empirical evidence does not provide definite conclusions about the effects of the privatization of electricity distribution utilities in Latin America because some important variables, such as the quality of service, are missing in the analysis (Estache & Rossi, 2004). According to Macedo (2004), researchers could improve cost-efficiency studies by incorporating a measure of quality of service in the analysis because a trade-off between the quality of service and the reduction of costs exists. Moreover, researchers have identified that the level of quality of service in the electric industry is diminishing progressively, negatively affecting consumers' acceptance of the reform (Berg, 2006; Costas, 2006; Shirley, 2004). Therefore, a relevant issue requiring research involves understanding why electric distribution utilities are lowering the quality of service. The privatization process seems to omit a policy of quality of service because the regulatory regime does not provide explicit signals that oblige the utilities to invest in and to expand on the quality of service (Costas, 2006).

In developed countries, researchers have made some effort to explain empirically why the utilities lower the quality of service. The studies occurred mainly in the telecommunication sector (Ai & Sappington, 1998; Ai & Sappington, 2002; Clements, 2001). Recently, in Latin America, Andres, Foster, and Guash (2006) elaborated on an analysis of the changes of the performance indicators of the electric distribution utilities and found that privatization caused significant improvements in labor productivity, efficiency, and product or service quality in the short term, in contrast to the findings of other researchers. Nonetheless, Andres et al. recognized that ownership does matter and recommended further research on the differences among regulatory regimes, investors, and sector characteristics.

Thus, addressing the quality-of-service problem appropriately requires research to determine why the quality of service in Latin America is diminishing after the reform. Latin America constitutes a natural laboratory where countries coexist with different regulation regimes,

mechanisms of monitoring, and ownership, which presents an opportunity to test how these differences influence the level of quality of service.

## Statement of the Problem

In Latin America, 75% of the population rejects privatization (Panizza & Yañez, 2006; Shirley, 2004). The promised reform benefits, which included lower prices, improved quality of service, and increased level of access, have not been realized (Millan, 2006). A result included risking the foreign investment of about \$10 billion because of the threat of nationalization (Kikeri & Nellis, 2004).

After the privatization in Latin America, researchers analyzed prices and costs extensively (Alva & Bonifaz, 2004; Estache & Rossi, 2004; Farsi & Filippini, 2004; Fisher et al., 2003; Rodríguez Pardina et al., 1998; Rudnick & Zolezzi, 2001). However, very few studies included an analysis of the quality of service. No studies exist to explain the factors that influence the quality of service provided by the electric distribution utilities (Andres et al., 2006; Estache & Rossi, 2004; Jamasb, Motta, Newbery, & Pollitt, 2005); thus, this study may fill the gap. The results of this study may help regulators and policymakers to design future policies in Latin America and other developing countries to reach a compromise and promote legitimate outcomes for both utilities and consumers.

## Purpose of the Study

The essence of this quantitative methodology research will be to examine the influence that regulation regimes, mechanism of monitoring, and ownership have on the quality of service provided by Latin American electric distribution utilities. This study, involving a quantitative methodology, will include an improved econometric model adopted from those developed by Ai and Sappington (1998), Clements (2001), and Ter-Martirosyan (2003). The dependent variable will be the level of quality of service measured by the following indices: System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI). The independent variables will be the electric distribution infrastructure investment (length of aerial and underground network per consumer), the number of switches (switches per length of medium voltage network), energy sales (kWh per customer), and operation and maintenance expenses (O&M per length of network). The dummy variables will be regulation regime (rate of return, price cap, and model firm), monitoring quality of service (high, medium, and low mechanism), and ownership (private and state-owned).

## Significance of the Problem

One important reason for this study is that many researchers who have tested the results of the reform in Lat-

in America have neglected the issue of quality of service (Estache & Rossi, 2004). In the first decade since privatization, as a product of the lack of information, the focus of studies was mainly performance evaluation, which helped to explain the improvement in cost efficiency and profitability of the privatized firms. Recently, however, researchers have been recommending an analysis of the quality-of-service factor due to its noticeable reduction (Berg, 2006; Costas, 2006; Millan, 2006; Shirley, 2004).

A second reason for the study is that in Latin America, a lack of studies that involve analyzing the factors of regulation regimes, ownership, and environmental characteristics and their influence on the decisions of the electric distribution companies regarding the provision of quality of service is evident (Andres et al., 2006). The results of this study may clarify whether a significant relationship exists between the regulatory regimes, mechanism of monitoring, and ownership and the level of quality of service of electric distribution utilities in Latin America. The regulation regime, constructed on the economic regulation theory, is a fundamental issue that influences the economical decision making of the utility (Kidokoro, 2002; Sheshinski, 1976; Spence, 1975). The point that regulation regimes are related to the economical signals, which influence the level of investments and expenses oriented to quality of service, is important and requires analysis in the context of Latin American countries because applying the outcomes of studies conducted in developed countries is not appropriate (Estache & Rossi, 2004). Similarly, empirical proof of the influence that the mechanisms of regulation have on the provision of quality of service in Latin America is required (Kriehn, 2005; Lewis & Sappington, 1991).

In addition, analyzing the influence the type of ownership has on the level of quality of service of Latin American electric distribution utilities is important. The analysis may shed light on the theoretical approach of incomplete contracts, which includes the argument that public utilities provide better quality of service than private utilities when the standards of quality of service and costs recognition have not been fully specified (Hart, Shleifer, & Vishny, 1997). Moreover, this study will incorporate panel data, following the recommendation of many researchers, to capture the temporal variability of the factors affecting the level of quality of service (Jamasp et al., 2005). This study may fill the gap in the literature and may contribute an analysis of the influence that the theories of regulation and contracts have on the level of quality of service provided by natural monopoly firms in the context of developing countries.

## **Nature of the Study**

Using a quantitative design will be appropriate according to the purpose of this research. Following the empirical works of Neuberger (1977), Ai and Sappington

(1998), Clements (2001), and Ter-Martirosyan (2003), an improved econometric model will aid in capturing the relationship between the quality of service and the independent variables of capital, labor, and demand. Neuberger (1977) elaborated a heuristic argument supporting the use of network variables as structural variables—the length of networks, capacity of transformer, and level of consumption per consumer—to relate to the production efficiency of an electric distribution utility. Later, Ai and Sappington (1998) and Clements (2001) produced an econometric analysis that related telecommunication infrastructure and labor to the quality-of-service index. Ter-Martirosyan (2003) improved the econometric assessment for application to the electric industry in the United States of America testing the relationship between the variables of capital, labor, and regulatory regimes and the level of quality of service.

The aim of this study will be to determine how the political and institutional variables relate to the level of quality of service. For this purpose, modification of the econometric model elaborated by the above-mentioned researchers will occur to capture the interrelation between the regulatory regimes, the mechanism of monitoring, and ownership and the quality of service in the Latin American setting. The study will be longitudinal and will incorporate panel data of a 5-year period (2002-2006). Use of STATA software will support the analyses. Data collection will occur through a field survey of primary and secondary sources. Data sources will include regulatory bodies, nongovernmental organization databases, and the utilities of Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela).

## **Research Questions**

1. How do the regulation schemes affect the quality of service provided by the electric distribution utilities in Latin America?
2. How does the monitoring mechanism affect the quality of service provided by the electric distribution utilities in Latin America?
3. How does ownership affect the quality of service provided by the electric distribution utilities in Latin America?

## **Hypotheses**

The regulation regimes influence the quality of service. Thus, testing of the following hypotheses will occur:

$H_1$ : The rate-of-return regulation (RORR) regime favors a better quality of service than the price-cap regime.

$H_2$ : The RORR regime favors a better quality of service than the model-firm regulation.

The degree of monitoring influences the quality of

service. Thus, testing of the following hypothesis will occur:

$H_3$ : The higher the degree of monitoring, the better the quality of service.

The type of ownership influences the level of quality of service provided by the electric distribution utilities. The hypotheses for testing will include the following:

$H_4$ : The private firm harms the quality of service in comparison with the politically controlled public firm.

$H_5$ : The private firm harms the quality of service in comparison with the influenced public firm.

$H_6$ : The private firm harms the quality of service in comparison with the independent public firm.

## Theoretical Framework

The study will occur within the field of economic regulation, from which emerged theories supporting private firms operating natural monopoly markets under the supervision of a regulator. The electricity sector reform has multidimensional factors that interact. The exogenous factors considered will include politics, economics, social factors, and institutional endowment, and the endogenous factors considered will include regulatory policies and market structure. Together, as illustrated in Figure 1, they influence the outcomes of the reform: (a) prices, (b) quality of service, (c) access to service, and (d) profits (Berg, 2001).

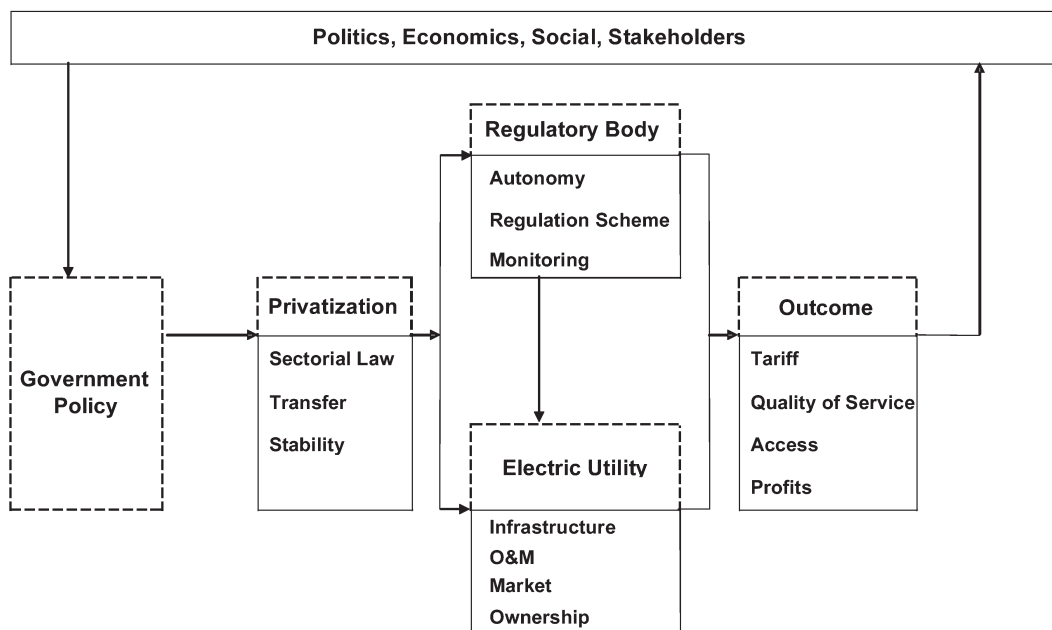
Therefore, the behavior of an electric distribution utility in terms of pricing, cost cutting, quality of service, and network expansion follows mainly the rules set in the regu-

lation policy and the related market structure (Berg, 2005). Different schemes or regimes governed the setting of prices. The early RORR (cost-plus regulation) was the traditional scheme with the prices reflecting in the rate base all the cost incurred by the firms. This signal resulted in an overinvestment and overplating of the quality of service.

In the 1980s, the theory of regulation evolved introducing a form of competition to the natural monopoly of electricity, gas, and water. Introduction of price-cap regulation and yardstick competition aided in setting prices based on cost efficiency, with the price related to the maximum price for a period of 4 to 5 years that a firm could charge the consumer. This scheme implicitly guided the firm to reduce costs and assure the consumer of no tariff increment.

The theories of principal-agent, right of property, bureaucracy, influence, and commitment conceptualized that because private firms focus on their profitability, they perform better than public firms perform (Perotti, 2004; Pollitt, 1995; Pollitt, 1997; Shleifer & Vishny, 1994). Most of the empirical studies occurred in developed countries, and developing countries reflect the same results. Few studies cast doubt on these findings. For example, Pollitt (1995) found that private and public firms in the United Kingdom perform similarly, but in the case of Latin America, Fisher et al. (2003) discovered that public Chilean firms perform better than private firms do. Thus, the outcomes are not completely conclusive. However, none of the researchers touched on the issue of quality of service, which nowadays has become an important factor that affects the sustainability of privatization. Only recently have researchers identified the decline in the quality of service as an important problem that requires a solution because

Figure 1. Multidimensional factors of reform sector.



such a problem can significantly affect the outcomes of efficiency of private firms (Millan, 2006; Nellis, 2004; Shirley, 2004).

Spence (1975) and Sheshinski (1976) developed an economical model that illustrated that under the price-cap scheme, the firms that cut costs adversely affected the level of quality of service as the managers concentrated more on profits. Since the end of the 1990s, researchers have examined the issue. Some studies in the telecommunication industry showed that under price-cap regulation, the quality of service of firms had decreased or remained the same (Ai & Sappington, 1998; Ai & Sappington, 2002; Clements, 2001). In 2003, an empirical study for the electrical distribution utilities in the United States indicated that the price-cap regime affected the SAIDI and SAIFI index of quality of service (Ter-Martirosyan, 2003).

Berg (2006) proposed that the factor that could explain the diminishing quality of service was the regulation scheme adopted during privatization. Lewis and Sappington (1991) and Noam (1990) expressed that the mechanism of monitoring could be a factor. However, Hart et al. (1997) emphasized that the incomplete contracts between the firms and government were the cause. Considering these findings, this research will involve developing an econometric model.

Ai and Sappington (1998) elaborated an econometric model to analyze the effect that price-cap regulation had on quality for the telecommunication industry and found no systematic link between the two. Additionally, Clements (2001) discovered a correlation between regulation-by-incentive schemes and the declining quality of service. Ter-Martirosyan (2003), based on the precedent works, elaborated an analysis for the electric industry and found that the regulation-by-incentive scheme and some kind of monitoring mechanism affect the quality of service.

Ter-Martirosyan (2003) developed an econometric model and considered the following independent variables to explain the level of quality of service: service territory, average income per capita, length of aerial network, length of underground network, ratio of generation to total energy sold, and weather. These independent variables do not explain the availability of a sufficient network capacity to guarantee consumers a long-term supply of electricity. Thus, this study will include a new variable that reflects investment for the improvement of the capacity of existent networks.

Furthermore, because the cited model does not include a variable to explain the avoidance of power outages and interruptions in the supply, the study will include another new variable that reflects investment in switches (Brown, 2002; Gönen, 1986). The previous model did not indicate a variable for the costs of operation and maintenance. With respect to the variables of control, no previous models have reflected either the type of ownership or the mechanism of monitoring. This research will include both these variables considering the corresponding categories

to promote a more precise explanation in the Latin American setting.

The study will include the following factors as dependent variables: SAIFI, which measures the degree of continuity of the electric service, and SAIDI, which measures the time firms take to reconnect the electricity after an interruption. The independent variables will include the following: total length of aerial network, total length of underground network, number of switches, costs of operation and maintenance, and annual sales of energy per firm. Neuberger (1977), Salvanes and Tjøtta (1998), Ter-Martirosyan (2003), Estache and Rossi (2004), Andres et al. (2006), and Farsi, Fillipini, & Greene (2006) used the first three variables extensively. However, according to Brown (2002) and Gönen (1986), following a theory for the calculation of the reliability of the electric distribution systems, the number of switches represents more accurately the outcomes of the quality of service due to its link with the distributor's capacity of maneuver to avoid interruptions or reduce the time of recovery of the electric service.

The independent dummy variables will include the type of regulation scheme, evaluated according to the RORR, price-cap regulation, and model-firm regulation. A second dummy variable will be the mechanism of monitoring, evaluated according to its grade of enforcement as high, medium, or low. The last dummy variable will be the type of ownership, private or public. According to Centeno and Serra (2007), in Latin America, a worthy consideration is that evaluation of the private dummy variable should occur according to the origin of the investor, subclassified as European, American, or regional/national. In addition, subclassifications of the public dummy variable will include controlled public firm, public influenced firm, and public independent firm.

## **Definition of Terms**

*Electric distribution utility:* An electric distribution utility is a firm that commercializes electricity in concession (Jamasb & Pollitt, 2007).

*Quality-of-service monitoring:* Quality-of-service monitoring involves a regulator controlling the level of quality of service provided by the electric distribution utility (Holt, 2004).

*Rate-of-return regulation (RORR):* RORR is a scheme of regulation that recognizes the physical assets of the utility (also called cost-plus regulation) (Gómez & Rothwell, 2003).

*Regulation by incentives:* Regulation by incentives is a broad category of regulations that includes price cap, yardstick, and model firm (price cap + yardstick) (Gómez & Rothwell, 2003).

*SOE:* An SOE is a state-owned enterprise (Ramamurty & Vernon, 1991).

## Assumptions

The first assumption will be that the SAIDI and SAIFI indices of quality of service applied to the electric distribution utilities are standardized international indices. The second assumption will include that the data for the period studied will reflect accurate compilation because the utilities, regulators, and other organizations have expended great effort in its collection. The third assumption will be that the utilities will complete the questionnaires because the research will involve working with data considered public information. The fourth assumption will include that the variables of the studied framework have a degree of applicability and generalizability to the electrical sector in developing countries. The final assumption will be that the distribution utilities under study with the same scheme of regulation will respond similarly in the Latin American context.

## Limitations

1. The study will be limited to the availability of information for the selected period (2002-2006).
2. The study will be limited to the utilities who agree to participate voluntarily if the information is not available on public websites or in publications.
3. The validity of the study will be limited to the homogeneity of the studied population.
4. The study will be limited to regions with similar characteristics to Latin American countries.

## Delimitations

The study will involve the collection of information on the electric distribution utilities in Latin America. The focus of the study will be examining the effect of the regulatory regimes, monitoring, and ownership on the level of quality of service provided by electric distribution utilities. Mexico's regulation regime is not comparable with the regulatory regimes of the other Latin American countries, so Mexico will not form part of the study.

## Summary

The decline in the quality of service of electric distribution utilities in Latin America is a topic requiring investigation because of its effect on the sustainability of privatization (Millan, 2006; Nellis, 2004; Shirley, 2004). The quality of service could be a hidden cost of privatization because the policies of regulation have neglected the quality-of-service issue (Costas, 2006). A factor related to the regulatory regimes that provide economical incentives to the firms could explain the reduction in quality (Berg, 2006; Kidokoro, 2002; Sheshinski, 1976; Spence, 1975). In addition, the monitoring mechanism of the regulator to supervise the utilities could be a factor (Ajodhia

& Hakvoort, 2005; Kriehn, 2005; Lewis & Sappington, 1991; Noam, 1990). Furthermore, the ownership of the utility could be a factor due to the existence of incomplete contracts where the government has not explicitly set the requirement for the quality of service, giving the private firms an incentive to reduce costs, which affects the level of quality of service (Hart et al., 1997).

This study may fill the gap in the literature relating to the Latin American setting. The study will involve developing an econometric model to analyze how regulation, monitoring, and ownership influence quality of service in developing countries. In the next chapter the characteristics of the electric distribution system, the definition of quality of service, the regulatory regimes, the mechanism of monitoring, and ownership will be addressed to understand their relation to the quality of service.

## CHAPTER 2: LITERATURE REVIEW

The research indicates that regulation schemes, monitoring of quality of service, and ownership influence the level of quality of service provided by the electric distribution utilities (Baron, 1981; Berg, 2006; Clements, 2001; Costas, 2006; Hart et al., 1997; Kidokoro, 2002; Noam, 1990; Sheshinski, 1976; Spence, 1975; Ter-Martirosyan, 2003). Berg (2001) developed a conceptual framework that outlines key links between public policy, basic industry conditions, and sector performance. The regulatory policies set the rules (price setting and quality standards) that restrain the behaviour of the firm, which influences the performance of the sector in terms of pricing, cost-cutting, provision of service, and network expansion. The regulation by incentives mostly adopted in sector reforms does not explicitly reflect consideration of allowances for quality of service.

The electricity distribution utilities operate under a natural monopoly where the quality of service cannot be differentiated. This particular feature causes the elasticity of demand not to affect the price, thus giving the utilities strong incentives to cut costs, which deteriorates the quality of service (Baron, 1981; Kidokoro, 2002; Sheshinski, 1976; Spence, 1975). In addition, Lewis and Sappington (1991) found that the quality of service is higher when the quality of service is verifiable. When an imperfect public monitor of delivery quality is available in the natural counterpart, the welfare of both the buyer and the supplier increases with the accuracy of the monitor. In the case of the electric industry, the public monitor is the regulator.

Furthermore, the incomplete contracts of concessions between the government and private firms drive the private distribution utilities, in their goal of being more profitable, to reduce or eliminate the investments for improving or maintaining the electric distribution infrastructure, which affects the quality of service (Hart et al., 1997). According to Costas (2006) and Berg (2006), the level of quality of service has been diminishing progressively, impacting

negatively on consumers' acceptance of the privatization, putting at risk the legitimacy and credibility of the reform. The purpose of this literature review will be to understand the electric distribution utility industry, to identify the regulation schemes and their influence on the quality of service, to explain the types of monitoring of quality of service, and to examine the influence of ownership.

## **The Electric Distribution Industry**

This section reflects the main characteristics of the electric distribution industry and their relation to quality of service.

### **Electric Distribution Activity**

Electricity is essential for modern life, and electric utilities provide the service. The product has the following technical and economical features: (a) electricity cannot be stored, (b) investment in electricity involves a long-run recovery, (c) the electricity network has strong externalities, (d) the industry has strong economies of scale and scope, and (e) the network takes a long time to build (Guash & Spiller, 1999; Höllriegel, 2007). The activity of generation involves the production of electricity by hydro or thermal power plants. Transmission is the activity related to the high-level voltage transportation of energy produced by the power plant to the cities or industries. Distribution involves delivering low-voltage electricity by local networks consisting of overhead or underground lines, cables, switchgear, transformers, control systems, and meters to transfer electricity from the transmission system to customers. The supply or retailing function includes metering, billing, and selling electricity to end-users (Edvardsen & Førsum, 2002; Jamasb & Pollitt, 2007).

Despite the considerable technological progress of the industry, the role of distribution networks within the electricity supply industry has largely remained unchanged (Jamasb & Pollitt, 2007). Network industries include technologies through which provision of services occur over a network of spatially distributed points with distinct demand characteristics. Demand characteristics vary according to customer groups (urban or rural), space, and quantities supplied (Neuberg, 1977; Salvanes & Tjøtta, 1998).

### **Objective of the Electricity Industry**

The goal of the electricity distribution business is to satisfy the customers' need for electricity, to ensure the quality of electricity supply, and to yield profits for the owners. Public policy creates incentives involving behavioral restraints. These incentives relate to price, quality-of-service requirements, and mandates for system expansion. Sector regulators use cost-plus regulation, or rate-of-return regulation (RORR), and price-cap mechanisms for constraining prices (Berg, 2005).

In particular, policymakers and regulators have widely failed to implement a formal treatment of quality of service. This oversight is especially problematical because of the interactions and trade-offs between utility costs (capital as well as operating and maintenance expenditures) and quality of service (Growitsch, Jamasb, & Pollitt, 2005). The public acceptability of prices, quality of service, and access to service all affect the political and, thus, the regulatory climate. The efficiency of firms depends on the ability of investors to capture the benefits from good performance and on the firm's ability to reward key decision makers (Berg, 2001).

Sector performance affects another element, the credibility of the system to private and public investors (Berg, 2005). According to Hart et al. (1997), the ownership of the utility can affect the quality of service in its goal of cost efficiency and profitability. The sustainability of the regulatory process depends on public acceptance of the outcomes, which determine the legitimacy of the process in the eyes of citizens (Berg, 2001).

### **Natural Monopoly and Regulation**

According to the economic concept of subadditivity, one firm providing a local distribution of electricity is less costly than multiple firms, so the electric distribution activity is considered a natural monopoly (Growitsch et al., 2005; Kessides, 2004; Salvanes & Tjøtta, 1998). Three major interest groups exist in the electricity distribution business: customers, utilities, and the government. The utilities, either private or state-owned, aim to reach the outcomes imposed by owners and the regulator.

Because the captive consumer expects both a reasonable price (tariff) and quality of service, regulation is necessary. The regulator who performs the regulation must be independent, accountable, and resistant to corruption by either the private provider or the state. The regulation contains objectives for efficiency improvements to reduce costs and, hence, tariffs. Thus, regulation is essential to protect consumers against monopoly power abuses and assures investors of fair treatment (Honkapuro, Lasilla, Partanen, Tahvanainen, & Viljainen, 2004; Kikeri & Nellis, 2004).

Regulation must ensure that tariff setting allows the utility to recover its investments with a reasonable return (Rudnick & Zolezzi, 2001). Traditional regulation assumes that regulators have detailed information of the technology, costs, and consumer-demand attributes facing the firms they regulate and can somehow impose cost-minimization obligations on regulated firms, but in reality, regulators have incomplete information (Joskow, 2006). Regulation schemes have evolved over time. The traditional RORR has changed to regulation by incentives, but its adoption in recent years has given rise to concern for the declining quality of service caused by profit maximization (Growitsch et al., 2005).

## Parameters of Quality of Service

In the activity of electricity distribution, a common distinction is evident among three different quality dimensions: reliability, voltage quality, and commercial quality. Of the three dimensions, reliability is by far the most important quality feature in electricity distribution because the whole electricity supply depends critically on the functioning of the distribution networks. The cause of over 90% of the interruptions experienced by customers is faults in medium and low voltage (Ajodhia & Hakvoort, 2005).

To sum up, the electric distribution industry is a complex system that involves special characteristics of electricity, which imply a natural monopoly. Regulation is required to promote efficiency. The regulator by means of different schemes sets the tariffs that allow for the utilities and investors to recover their investment, and for the customers to pay a fair tariff.

Regulation by incentives causes the utilities to maximize their profits, which results in a lowering of the quality of service. This problem may affect the approval of the regulatory policy and could weaken the sustainability of the electric industry reform. Therefore, the research study will involve investigating the influence of the parameters of regulation policies (mechanisms of regulation and monitoring) and ownership on the outcomes of the quality of service.

## The Quality of Service in the Electric Distribution Industry

This section includes a discussion of the paradigms of quality of service and the dimensions of quality of service in the electric distribution industry.

### Definition of Quality of Service

Garvin (1984) maintained that five major approaches define quality: (a) the transcendent approach of philosophy; (b) the product-based approach of economics; (c) the user-based approach of economics, marketing, and operations management; (d) the manufacturing-based approach of operations management; and (e) the value-based approach of operations management. According to *the transcendent approach*, quality is synonymous with innate excellence. It is both absolute and universally recognizable, a mark of compromising standards and high achievement. Nevertheless, proponents of this view claim that one cannot define quality precisely; rather, according to Garvin, quality is a simple, unanalyzable property that people learn to recognize only through experience.

*The product-based approach* indicates quality as a precise and measurable variable. Differences in quality reflect differences in quantity of some ingredient or attribute of a product. This approach lends a vertical or

hierarchical dimension to quality because of the possible ranking of goods according to the amount of the desired attribute they possess (Garvin, 1984).

The user-based approach definition reflects the opposite premise that quality “lies in the eyes of the beholder” (Garvin, 1984, p. 27). Individual consumers have different wants or needs, and the goods that best satisfy their preferences are those that they regard as having the highest quality. The approach is an idiosyncratic and personal view of quality, one that is highly subjective.

*The manufacturing-based approach* involves a focus on the supply side of the equation and is primarily concerned with engineering and manufacturing practice. Virtually all manufacturing-based definitions illustrate quality as conformance to requirements. Excellence equates with meeting specifications and with “making it right the first time” (Garvin, 1984, p. 27).

Finally, *the value-based approach* takes the idea a step further. The approach includes a definition of quality in terms of costs and prices. According to this view, a quality product is one that provides performance at an acceptable cost.

Thus, several paradigms show that no consensus exists on the definition of quality because each paradigm emphasizes different dimensions of quality. The implications are that the relations of (a) utility of distribution-to-utility of generation, (b) utility-to-regulator, and (c) utility-to-consumer may be complicated. The goal of the utility is to satisfy the consumers’ quality demands, regardless of whether the service meets the various technical standards. However, the technical standards will be paramount for the regulator (Clements, 2001).

### Dimensions of the Quality of Service

Distinguishing between the three different quality dimensions for electricity distribution is common. First, commercial quality concerns the quality of relationships between the electricity distribution utility and its consumers. For example, timely installations or connections, prompt responses to customer complaints, efficient billing practices, safeguarding of customer accounts, and accuracy of customer information (Holt, 2004; Pinter & ReKettye, 2005).

Second, power quality, also known as voltage quality, covers a variety of disturbances in the voltage waveform. The main parameters of voltage quality are frequency, voltage magnitude and its variation, voltage dips, temporary or transient overvoltages, and harmonic distortion. From the customer’s perspective, a power quality problem is any electric supply condition that causes appliances to malfunction (Brown, 2002; Lopez, 2007).

Third, the quality dimension of reliability, which measures the ability of the continuity of the network, includes two main elements, namely adequacy and security. *Adequacy* relates to the availability of a sufficient net-



work capacity to guarantee consumers a long-term supply of electricity. *Security* describes the avoidance of power outages and interruptions in the supply to customers (Giaccchino & Lesser, 2007; Gönen, 1986).

Key definitions relating to distribution reliability include the following (Brown, 2002; Gönen, 1986):

1. A *contingency* is an unexpected event, such as a fault or an open circuit.
2. A *fault* is an interruption caused by a short circuit.
3. An *outage* occurs when a piece of network is de-energized.
4. A *momentary interruption* occurs when a customer is de-energized for less than a few minutes. Most momentary interruptions result from reclosing or automated switching.
5. A *momentary interruption* event consists of one or more momentary interruptions within several minutes.
6. A *sustained interruption* occurs when a customer is de-energized for more than a few minutes. Most sustained interruptions result from open circuits and faults.

The reliability indices are a statistical aggregation of reliability data for well-defined sets of loads, components, or customers. Most reliability indices are averaged values of particular reliability characteristics for an entire system, operating region, substation service territory, or feeder. The most widely used reliability indices are averages that weigh each customer equally. Customer-based indices are popular with regulating authorities because a small residential customer is as important as a large industrial customer. The indices have limitations but are generally good aggregate measures of reliability often used as reliability benchmarks and improvement targets (Brown, 2002).

Two methods exist to calculate reliability. The majority of utilities calculate indices based on the number of customers per outage and the duration of the outage. Another group calculates indices based on the load lost, but their databases were not as extensive as the indices based on the number of customers. According to Burke (1994), various groups, such as the Institute of Electrical and Electronic Engineers (IEEE), have defined indices. The formulae for customer-based indices follow:

System Average Interruption Frequency Index (SAIFI):

$$\text{SAIFI} = \frac{\text{Total number of customer interruptions}}{\text{Total number of customers served}} \text{ /year}$$

System Average Interruption Duration Index (SAIDI):

$$\text{SAIDI} = \frac{\sum \text{Customer interruption duration}}{\text{Total number of customers served}} \text{ hr/year}$$

Although establishment of numerous dimensions of quality of service is possible, outage-related indices are the only relatively widely accepted measures of quality across the electric utilities. The principal reliability indices are average duration (SAIDI) and average frequency of electric outages (SAIFI) (Meyrick & Associates, 2002; Ter-Martirosyan, 2003). The Customer Average Interruption Duration Index (CAIDI) is a measure of how long an average interruption lasts, and is used as a measure of utility response time to contingencies. The CAIDI index is not taken into account for this research as the CAIDI can be distorted by increasing the number of short interruptions (Brown, 2002).

To summarize, the quality of service of electric utilities is a broad concept that includes different dimensions. However, the literature on mechanisms of effective and quantitative measurements includes a focus on indices of the average number of interruptions and the average interruption duration. For the purpose of this research, the major dimension of the quality of service of the electric distribution system will be the SAIDI and SAIFI indices.

## Regulation Schemes and Quality of Service

This section includes an assessment of the main regulation schemes used for the regulation of distribution tariffs to address their economical signals and relation to the quality of service.

### Rate-of-Return Regulation

The RORR or cost-plus regulation is a traditional scheme of regulation. The setting of the tariff involves two steps during the rate case or regulatory review. First, the rate level determination involves (a) identifying allowed costs and investments and (b) setting an allowed rate of return so that the utility will receive the appropriate level of earnings on its investment (Gómez & Rothwell, 2003; Parker & Kirkpatrick, 2005). Second, the rate structure determination deals with setting tariffs for different customer classes and products, which permits the utility to recover the revenues required to earn its allowed rate of return (Gómez & Rothweell, 2003).

During the regulatory review, tariffs are set based on a test period (generally, the previous accountancy period) and remain in effect until the next review. In practice, the utility or the regulator can initiate regulatory reviews (Laffont & Tirole, 1993). The utility can argue that the current tariffs are too low because the costs allowance or the allowed rate of return is too low. The regulator can argue the opposite to request a rate case (Gómez & Rothwell, 2003).

After the utility and the regulatory staff present detailed accounting information and negotiation occurs between the regulator, agency staff, and the utility, the regulator determines the appropriate level of expenses and sets

the allowed rate of return. The regulator audits the firm's costs carefully to reveal cost padding and unnecessary capital expenditures to avoid the increase of the asset base (Höllriegel, 2007; Parker & Kirkpatrick, 2005). Then the regulator attempts to choose a fair and reasonable rate of return for capital. Finally, the utility adjusts the tariffs to yield the new rate of return allowed by the regulator (Lafont & Tirole, 1993).

The required revenues remain fixed during the regulatory lag (period between two consecutive rate revisions), which provides an incentive for the utility to reduce costs. The utility earns higher rates of return by incurring lower costs than the costs anticipated in the rate base. If costs are higher than anticipated, the utility earns less than the allowed rate of return (Gómez & Rothwell, 2003). Another important instrument that provides incentives for regulated firms to be efficient is the determination of whether a particular investment is to be included in the rate base. According to Gómez and Rothwell, many regulators use original cost valuation (the amount that the company originally paid for its plant and equipment less depreciation) and focus on the selection of the allowed rate of return.

An asymmetric information problem is evident throughout regulatory reviews. The problem results from an asymmetry of information between a regulator who wants something done and the electric utility that must do the work (Gómez & Rothwell, 2003). Another problem occurs when the allowed rate of return exceeds the actual cost of capital; the firm has a strong incentive to overinvest and inflate the capital stock, known as the "Averch-Johnson effect" (Averch & Johnson, 1962).

Overcapitalizing is associated with an oversupply of quality because quality is typically a capital-using attribute (Spence, 1975). Thus, both prices and quality levels will be too high. Empirical studies show that under RORR, existing reliability levels in the electricity industry are generally higher than optimal from a social point of view (Ajodhia & Hakvoort, 2005). This situation includes additional costs and, thus, a higher price: Consumers will be paying too high a price for too high a quality level, so-called gold plating (López, 2007).

In addition, the quality of output may rise if RORR encourages capital intensity, and if capital is normally required to increase service quality, the result may be excessive quality (Baldwin & Cave, 1999; Sappington, 2005). If quality is capital intensive, quality levels will automatically tend to be high, and less need for explicit quality regulation will exist. In this scheme, the main responsibility of providing a good quality of service remains with the utility instead of with the regulator (Kahn, 1988). According to Kahn, the government supervisor intervenes only where objective standards can be set or after an event when the monopolistic performance has been obviously bad. Under RORR, regulators can indirectly escape the quality regulation problem, but the escape comes at a cost of lower efficiency.

Spence (1975) emphasized that under regimes of monopoly, product characteristics are not usually supplied under the pressure of the market, and for this reason, regulation is beset with difficulties when price and quality are decision variables. The difficulties are informational, and without the necessary information, the RORR may be attractive as a second-best. Consequently, the RORR may be a substitute for quality regulation. Finally, following Kahn (1988) and Spence (1975), one might assume that under RORR, the quality of service is not directly regulated but set by the utility.

Thus, RORR leads to higher levels of quality of service because the rate base includes the investments and allowances for maintaining and operating the electric installations. In addition, the regulator has no explicit need to deal with quality because the responsibility for a good quality of service lies with the utilities that must comply or face government intervention. Finally, under RORR, the utilities may overcapitalize their rate base to obtain both higher rates of return and higher levels of quality of service.

### **Regulation by Incentives**

Regulation by incentives is a form of utility regulation that strengthens the financial incentives to lower rates, lower costs, or improve nonprice performance compared with traditional RORR. The design and application of a regulation-by-incentives plan include a set of interrelated tasks: (a) set a baseline revenue requirement, (b) set the adjustment factors, and (c) design the control mechanism to meet specific objectives (Gómez & Rothwell, 2003). The most typical forms of incentive regulation with a long regulatory lag applied for setting tariffs in a power distribution utility are (a) price cap, (b) revenue cap, (c) yardstick competition, and (d) a hybrid system, a combination of price cap, revenue cap, and yardstick competition (Agrell, Bogetoft, & Tind, 2005; Gómez & Rothwell, 2003; Jamasb & Pollitt, 2007).

Under price-cap regulation (price cap or revenue cap), maximum (but not required) prices for utility services are set for several years regardless of the utility's own costs. Adjustment in subsequent years of maximum prices allowed during the first year occurs according to a prespecified set of economic indices and factors. For example, (a) maximum price or tariff, in the case of price cap; (b) authorized utility revenues in a year, in the case of revenue cap; (c) annual change in prices (the inflation index); (d) productivity offset; and (e) the adjustment factor for unseen events (Gómez & Rothwell, 2003).

Price-cap regulation provides the firm with an incentive for cost efficiency. Regulators do not recognize the actual costs in the rate base but rather concentrate simply on price ceilings. In this scheme of regulation, the formal price regulatory review and the commitment of the regulator using a price cap support the lack of revision of prices for a

period of time in between formal reviews, which promotes cost efficiency. After this period, not only will adjustment of prices occur, but also the consumers will benefit from the efficiency gain (Cowan, 2006; Höllriegel, 2007).

Furthermore, the formal regulatory review must take place in a reasonable period of time, every 4 or 5 years. This policy induces the utility to pursue savings in costs and to avoid public hostility toward the regulatory regime in view of the utility making large profits with prices well above costs of supply (Kriehn, 2005). Moreover, under price-cap regulation, the regulator provides the utility with only high-level incentives that promote some regulatory objective without interfering in the details of running the firm (Ajodhia & Hakvoort, 2005).

The central idea behind price-cap regulation is to control the prices charged by the regulated utility rather than to control its earnings (Uri, 2001). As a result, price-cap regulation gives firms an incentive to cut costs, which raises the concern that firms may achieve part of the cost reductions by decreasing quality (López, 2007). Germinal papers by Spence (1975) and Sheshinski (1976) theoretically showed that price caps led firms to reduce quality to cut costs and increase profits.

The difficulty of effective quality regulation becomes evident if one moves from RORR toward stricter price-cap regulation. Under RORR, no explicit need for quality regulation exists because quality is more or less safeguarded. However, under price-cap regulation, such safeguarding is not evident (Ajodhia & Hakvoort, 2005).

According to Fraser (1994), two situations exist in a relationship between price-cap regulation and the reliability of service provided by a private monopoly. Excluding reliability, the firm tends to protect profits by lowering the quality of service; however, including quality-of-service costs eliminates this tendency. Consequently, the exclusion of reliability of service from the price-cap formula means that although consumers experience protection from the cost increase, this protection occurs at the expense of a lower quality of service.

Empirical studies occurred mostly in the telecommunications industry. Ai and Sappington (1998) and Roycroft and Garcia-Murrilo, (2000) found that although regulation by incentives affects the quality of service, the results are not conclusive. Nonetheless, Clements (2001) claimed that a lower quality of service is associated with a monopoly environment under price-cap regulation. Weisman (2002) reported that Oregon and Idaho in the United States abandoned the regulation-by-incentives approach due to a reduction in the quality of service (as cited in Lopez, 2007). Ai and Sappington (2005) stated the following:

The implications for service quality are not clear. Because higher levels of quality of service can increase revenues, incentive quality regulation can enhance incentives to provide high-quality service to customers. On the other hand, because lower levels of quality can reduce operat-

ing costs, incentive regulation can diminish incentives to provide high-quality service. Thus, the overall effect of incentive regulation on service quality is ambiguous as a theoretical matter. (p. 202)

Kidokoro (2002) expressed that the use of price-cap regulation as a regulatory method presents a difficulty because even though a regulator gives the economical signals to make the utility lower its prices by imposing an upper limit on the price, the regulator cannot provide the utilities with incentives to improve their quality of service. According to Mikkers and Shestalova (2003), the cost-reducing incentives are especially strong in the short run but may have an adverse effect on investment in long-run objectives. In particular, a firm can delay an upgrade or the installation of new capacity, which may not affect today's performance but may result in the deterioration of performance in the future, influencing the quality of service. Furthermore, Burns (2003) argued that the direction for electric distribution utilities under price caps is to cut costs, especially operations and maintenance costs. These reductions of costs could result in worse reliability.

An empirical study within the electrical sector by Ter-Martirosyan (2003) illustrated that under regulation by incentives and in the absence of explicit regulation for quality of service, quality of service tends to decline. Ter-Martirosyan found that price-cap regulation led to worse quality performance in terms of an increase in the SAIFI. In addition, the researcher argued that price-cap regulation affects the cost structure of the firm; the impact on equipment (capital) is a long-term effect although the related changes in reliability may not be evident in the short term. Furthermore, Ter-Martirosyan argued that price-cap regulation affects the utility's expenditure on operations and maintenance. These cost reductions negatively affect the reliability of the service.

Under *yardstick competition*, the regulator sets a price cap for a firm based on the average cost of the other companies in the sector and allows the firm to keep the difference between the cap and the realized cost (Shleifer, 1985). Tangerås (2002) claimed that when regulating quantity, yardstick regulation results in lower quality than under individual regulation although, under the latter, the quality would be too high for some. In principle, the argument also holds for both price-cap and revenue price-cap regulation models. Mikkers and Shestalova (2003) indicated that the yardstick regulation involved unlinked prices from companies' own costs, providing firms with strong incentives to reduce cost and improve efficiency but resulting in the deterioration of the quality of service. Thus, price-cap, revenue-cap, and yardstick regulation schemes within the regulation-by-incentives approach together lead firms to reduce the quality of service.

The main *hybrid mechanism* for regulation in Latin American countries is the denominated model firm. The revenue of the utilities is established based on the optimization of a model firm, against which all distribution

concessionaire firms compete (Pollitt, 2005). Generally, the value added distribution (VAD) cost recognizes the remuneration of the electric assets and the expenses associated with (a) the network operation and maintenance, (b) capital of efficient electric installations, and (c) customer attention; the latter two expenses depend on the concession contract (Arnau, Mocarquer, Rudnick, & Voscoboinik, 2007; Giachino & Lesser, 2007). The regulator sets prices for distribution (the VAD) relative to an inflation rate for the next 4 years (Pollitt, 2005). Rainieri and Rudnick (1997) emphasized the following:

The model firm mechanism has proven effective in reducing costs and in conveying this greater efficiency to consumers of what is a simple mechanism where total distribution costs are reimbursed. If the tariffs set by the regulator fail to recognize properly the quality offered, we may have that the firm, when facing an incentive to reduce costs, has in hand a perverse incentive to reduce the quality offered, because it will try to protect its profits. (p. 287)

The hybrid mechanism mimics the later suggestions for price-cap regulation (Littlechild, 2003) and yardstick competition based on average costs in other similar firms (Shleifer, 1985). Tangerås (2002) argued that no matter the type of regulation-by-incentives approach used for price regulation, the utility always lowers the quality of service. Utilities only respond to explicit quality-of-service incentives. Taking into account the technical report of the Comisión de Integración Energética Regional (CIER, 2007), Table 1 illustrates the schemes of regulation adopted by Latin American countries.

In conclusion, regulation by incentives gives strong signals to the electric distribution utilities to improve their economic performance through cost reductions, which result in a decline in the quality of service. Spence (1975), Sheshinski (1976), and Kidokoro (2002) showed that

price-cap regulation leads the firm to reduce costs, which adversely affects the quality of service. The few empirical studies in the telecommunication and electricity fields in the United States showed that price-cap regulation affects the quality of service (Ai & Sappington, 1998, Clements, 2001; Ter-Martirosyan, 2003). Researchers have conducted no research in developing countries to test empirically the effect that different schemes of regulation have on the quality of service.

Two systems of price regulation exist: (a) RORR and (b) regulation by incentives; the former known as the traditional scheme, and the latter known as the new or modern scheme of regulation. Under RORR, the quality of service is the responsibility of the utility, which has a strong interest in providing good quality because investments and costs are recognized in the base rate. The regulation-by-incentives system does not recognize investments and costs for the quality of service explicitly, because the tariffs are set under a prospective model of efficiency with results reflected in a price cap. Because the utility is not responsible for the quality of service, it aims to increase its profits by a reduction of costs, which consequently affects the level of the quality of service. Thus, the quality of service is an important problem that emerges from the economic foundation of the regulation schemes.

This study will involve assessing the influence that the schemes of regulation have on the level of quality of service in Latin American countries. The outcomes of this study may add clarity to the debate on the privatization of natural monopoly public services and may help policymakers and regulators to deal with the quality of service problem appropriately. The solution of this important problem may help to consolidate the reform (privatization) in Latin America and encourage credibility and sustainability.

Table 1  
*Schemes of Regulation in Latin American Utilities*

Type of regulation	Countries	No. electric distribution utilities	Period of review
Rate of return	Costa Rica, Ecuador, Honduras, Paraguay, & Venezuela	32	Anytime
Price cap	Argentina, Bolivia, Brazil, Colombia, El Salvador, Nicaragua, & Uruguay	82	4-5 years
Revenue cap—yardstick (model firm)	Chile, Guatemala, Panama, & Peru	18	4-5 years

## The Quality-of-Service Monitoring

According to Spence (1975) and Sheshinski (1976), the monopoly firm under price-cap regulation has the incentive to lower costs, which adversely affects the quality of service, and Lewis and Sappington (1991) found that the quality of service is higher when the quality of service is verifiable. Kriehn (2005) stated that under price-cap regulation, regulators in developing countries would need to introduce service quality measures and monitor standards. In addition, Urbiztondo (2000) explained that historically a difference of quality of service exists between developed and developing countries. The former countries use RORR (or cost-plus regulation), which induces the utility to provide a high quality of service because the tariff permanently includes the investment and maintenance costs. Furthermore, Waddams Price, Brigham, and Fitzgerald (2002) indicated that one characteristic of network industries is the provision of a common level of quality across at least some groups of consumers (those supplied from the same section of a distribution system). In such cases, regulators have to determine which services they should set standards for and identify appropriate target levels and penalties.

Lewis and Sappington (1991) and Noam (1990) emphasized that in an environment of price-cap or incentive regulation, linking quality performance to financial rewards is necessary. Otherwise, pressure for quality shortcuts exists. According to Baker and Trémolet (2000), in developing countries, the quality-of-service standards tend to be high for the following reasons:

1. Providers have often inherited operating structures and tariffs from large-scale operations and are not used to considering low-cost options.
2. Providers base investment designs on the standards of developed countries.
3. Large private utility providers tend to focus on high-margin customers and frequently have no financial incentive to develop low-cost provision.

Joskow (2006) pointed out that quality-related incentives to cost control must include (a) two indices for distribution service interruption targeting the number of outages and the number of minutes per outage, (b) interruption payment obligations, (c) quality of telephonic attention to consumers, and (d) discretionary award based on surveys of customer satisfaction.

Ajodhia and Hakvoort (2005) described the various regulatory instruments:

Regulatory attention to network reliability has increased during the last few years. Different types of regulatory instruments can generally be classified as: a) indirect instruments, b) standards, and c) incentive schemes. *Indirect instruments* promote good quality of service by strengthening the information and negotiation position of customers. There are different methods

to achieve this. The regulator may require the firm to publish information about its performance or it may publish comparative overviews itself. Exposure to public criticism can motivate a utility to consider consumers' preferences for quality. *Standards* dictate a minimum performance level for a utility. Violation of the standard leads to a fine or tariff rebate. In general, two types of standards exist, overall and individual. *Overall standards* relate to network quality at the system level. *Individual standards* prescribe a minimum level of performance to be delivered to individual customers. *Quality incentive schemes* can be considered as an extension of a standard. Here, price and quality are closely related: the firm's performance is compared to some quality target, and deviations result in a price adjustment that can be either a penalty or a reward. (pp. 214-215)

Waddams Price et al. (2002) explained the following:

The economic regulator could incorporate quality concerns directly in the price cap, making the price or revenue allowed directly dependent on quality delivered. If quality increased a company would be allowed to raise its price, recouping some of the costs directly from the consumers who had benefited, and a degradation of quality would similarly be reflected in lower allowed prices. (p. 6)

Alternatively, the regulator could impose a particular level of quality (standard). Ideally, any degradation away from the optimum level should result in the utility confronting costs that are equal to the value of the total consumer losses. However, the standards have proved a powerful incentive for the utilities concerned, who have responded by improving their performance in almost every measure (Waddams Price et al., 2002).

The multidimensional nature of quality attributes complicates the measurement of quality of service, which means that, depending on their specific needs and expectations, customers perceive certain attributes to be of greater value than other attributes (Holt, 2004). Because quality is more important than quantity, Holt believed it prudent to start with fewer indicators and add to them as reliable data become available. Holt defined technical and commercial service standards:

Minimum service standards of quality-of-service apply to technical, commercial and commodity standards. Utility regulators generally have more direct oversight with respect to *technical* and *commercial* standards. *Technical standards* apply to reliability issues, such as the number and duration of service interruptions. *Commercial standards* apply to the direct transactions between the utility and the end user. Such standards are expressed in terms of measures and represent the minimum performance level that regulators expect from the utilities. (p. 194)

Regulators may apply rewards and penalties to each measure used to assess a utility's service quality or to measures aggregated into an index of overall service quality (Holt, 2004). In terms of incentives, it makes no difference whether this is in the form of a lower allowed reward or a penalty. Nevertheless, an attractive political and distributive argument exists that consumers who have suffered poor service should receive some compensation (Waddams Price et al., 2002). Rainieri and Rudnick (1997) pointed out the following:

The distribution firms' exposure to fines for offering an unsatisfactory service quality does not solve the issue of separating the incentive scheme with respect to quantity and quality. When the set tariffs underestimate the cost of quality, we will have that the substantial fines will only make the distribution firm offer a quality that is the minimum possible demanded. For instance, and thinking about the setting of a permitted voltage level fluctuation band, we will have that to protect its profits, the firm will tend to stay close to the band floor. (p. 287)

Lewis and Sappington (1991) noted that if both the buyer and supplier gain when an accurate public monitor of quality is available, they are likely to agree on institutional structures that facilitate third-party verification, such as testing and on-site inspections by independent parties. According to Laffont and Tirole (1993) and Sappington (2005), quality is verifiable when a third party (such as an enforcement agency) observes and, if necessary, documents the realized level of service quality. When quality is verifiable, basing financial rewards and penalties explicitly on realized service quality is possible. In contrast, enforcing such policies when realized levels of service quality are not verifiable will be difficult, if not impossible.

Tracy and Sappington (1992) emphasized that the optimal regulatory policy depends critically on the regulator's ability to monitor the firm's activities. The regulator must accurately measure the level of service to enhance the quality of service provided by the utility. Moreover, the optimal regulatory policy will be sensitive to the information available to the regulator. Sappington (2005, as cited in Jamasb & Pollit, 2007) argued that no simple policy solutions for

effective monitoring of quality of service exist, but the solutions depend on the information available to the regulator, institutional settings, and consumer preferences.

Taking into account the technical report of the CIER (2007), Table 2 illustrates the schemes for monitoring quality of service adopted by Latin American countries: high-powered, medium-powered, and low-powered monitoring. *High-powered monitoring* concerns the setting of a quality-of-service standard and its relation to penalties. *Medium-powered monitoring* involves the setting of a minimum quality-of-service standard with no penalties but includes measurement and publication of the results. *Low-powered monitoring* concerns the inexistence of standards of quality of service, or even if they do exist, they lack implementation.

To summarize, the electric distribution utilities in developed countries traditionally provide a good quality of service because of the extensive use of RORR (or cost-plus regulation). However, in Latin America, as a product of the reform in the electrical sector, the countries have mainly adopted the regulation-by-incentives scheme for setting prices, which calls for the intervention of a regulator to monitor the quality of service. To accomplish this task, regulators have had to adopt different schemes of monitoring: high, medium, and low. Understanding in which way these mechanisms of monitoring influence the level of quality of service obtained by the electric distribution utilities in Latin America is important because such information will help the regulator and policymakers to improve the policy of regulation. Definitely, the regulatory experience and the endowments of developing countries are different from those of developed countries. In this sense, the empirical results of this study may enlighten the economic regulation field because to date no empirical studies exist on this issue in Latin America.

## Ownership and Quality of Service

Growitsch et al. (2005) pointed out that since the 1990s, liberal models based on competition, economic incentives, and private ownership have been popular to achieve internal and external efficiency improvements in the public service sectors (telecommunications, electric-

Table 2  
*Monitoring Mechanisms in Latin American Utilities*

Type of monitoring	Countries	No. electric distribution utilities
High powered	Argentina, Bolivia, Guatemala, Panama, & Peru	29
Medium powered	Brazil, Chile, Colombia, & El Salvador	67
Low powered	Costa Rica, Ecuador, Honduras, Nicaragua, Paraguay, Uruguay, & Venezuela	32

ity, gas, and water) to benefit the consumers in the form of lower costs and higher quality of service. Nevertheless, the reformed industry has widely neglected the quality-of-service factor. Yarrow (1986) indicated the following:

Privatization is likely (but not inevitably) to lead managers to place greater emphasis on profit goals. Whether or not this in turn leads to an increase in economic efficiency depends upon a trade-off between market failures and deficiencies in governmental monitoring and control of public firms. In particular, it depends heavily upon both the degree of competition in product markets and the firm's regulatory environment. (p. 334)

In addition, Atkinson and Halvorsen (1986) observed the following:

The theoretical model is based on the hypothesis of utility-maximizing behavior by the managers of firms. Although utility-maximizing models of firm behavior have been available for many years, and the concept of utility-maximizing behavior underlies the property-rights approach to analyzing relative efficiency, a formal analysis of the joint implications of ownership type and regulation does not appear to have been undertaken previously. (p. 281)

Pollitt (1995), in a post reform study for the UK electrical distribution industry, concluded the following:

On the balance of theoretical evidence would seem to be that there is probably little difference in the incentives created by different regulatory regimes, designed to reduce the exploitation of monopoly power, and that the magnitude of the distortion which they introduce with respect to the incentive to minimize costs is likely to be small and declining over time, as regulation improves. Even if the general theoretical conclusion seems to be that private regulated monopolies tend to overinvest relative to the optimum, while public owned firms tend to have too much labour relative to the optimum, this still leaves it to empirical testing to determine the relative efficiency of both privates and municipal firms. (p. 21)

In addition, Bagdadioglu, Waddams, and Weyman-Jones (1996) found that private electric distribution utilities show better technical- and scale-efficiency scores. However, this result does not necessarily imply the success of private ownership in electricity distribution because technically and scale-efficient publicly operated distribution organizations are also evident.

According to Purdy (1997), the link between ownership and performance would appear to remain largely unproven. Pollitt (2000) and Renzetti and Dupont (2003)

emphasized that different theoretical arguments exist on why private ownership and market-oriented reforms might lead to greater efficiency. The main theories that sustain this declaration are (a) property rights theories, (b) bureaucracy theories, (c) influence theories, (d) economic regulation theories, and (e) commitment theories. On balance, these theories indicate that reform will lead to improved economic efficiency.

Shirley and Guash (2000) summed up the ownership or reform debate based on a review of some 50 empirical studies covering a variety of countries and sectors (as cited in Kikeri & Nellis, 2004). The summary reflects greater ambiguity about ownership in the theoretical literature than in the empirical literature. The clear majority of empirical studies illustrated that privatized, and private, firms perform better than state enterprises, a finding that is robust across sectors and market structures and across developed and developing countries. Megginson and Netter (2000) suggested, in their assessment of empirical studies on the privatization experience worldwide, that strong evidence exists that privatization improves operating performance (as cited in Renzetti & Dupont, 2003). Dewenter and Malatesta (2001) also claimed that government-owned firms must be less efficient or, at least, less profitable than privately owned firms.

Concerning the effect of ownership, Macedo (2004) claimed that no evidence exists that private firms are more efficient than public companies. A positive, significant relationship between private firms and costs is evident. This result is in accordance with the previous empirical study (Pollitt, 1995), which does not reflect evidence of a higher efficiency of private firms. Finally, the assessment by Estache and Rossi (2004) is worthy of mention. The authors argued that, overall, the empirical evidence does not provide definitive conclusions about the effects of the change of ownership and the regulation-by-incentives scheme on the efficiency of electricity distribution firms in Latin America because some important variables, such as the quality of service, are missing in the analysis.

In another vein of economic theory, Holmstrom and Milgrom (1991), through a comprehensive theoretical contract framework, showed that when an agent receives strong incentives to pursue one objective, such as profits, he or she might neglect other objectives, such as quality of service. In addition, Hart et al. (1997) built an argument, based on the contract theory, that public enterprise in a narrow range of circumstances may be superior, especially when full specification of the quality of service is not available. Indeed, critics of privatization often argue that private contractors would cut quality in the process of cutting costs because contracts do not adequately guard against this possibility. Shleifer (1998) observed that the narrow set of circumstances in which government ownership is likely to be superior includes the following: (a) op-

portunities for cost reductions that lead to noncontractible deterioration of quality are significant; (b) innovation is relatively unimportant; (c) competition is weak, and consumer choice is ineffective; and (d) reputational mechanisms are weak.

Perotti (2004) insisted that ownership makes a difference to incentives and, thus, actions because contracts are incomplete. In this context, ownership completes contracting because it assigns to the owner the set of residual control rights over uncontracted or unregulated contingencies. Thus, state ownership is justified when explicit regulation is difficult to implement because of nonverifiable contingencies. Furthermore, Kwoka (2005) asserted that studies of the performance effects of public versus private ownership, realized for the electric distribution utilities in North America, showed mixed evidence. Kwoka suggested that public enterprise (municipalities) might have an advantage in producing goods and services with quality attributes that are difficult to specify a priori. Kwoka elaborated on the debate:

Evidence concerning quality of service is imperfect, but there are some relevant data on the most common measure of quality, namely, reliability of distribution service. The values of System Average Interruption Duration Index (SAIDI) showed that public utilities perform better than private utilities when the size of the public utility is small (p.636). These results provide support for newer theories of public ownership, which identify possible advantages over private ownership in the provision of certain services (p.639). From a policy perspective, it cautions that the quest for superior performance is not simply a matter of prescribing privatization. There are identifiable circumstances in which public enterprise is an appropriate, if not perfect, policy prescription. Research and policy require a more sophisticated view of the effect of ownership on enterprise performance (p. 639).

Agrell et al. (2005) contended that irrespective of ownership, either investor-owned or publicly owned utilities, any natural monopoly poses a risk to society by accruing excess profits and costs at the expense of the consumers. The problem is the principal-agent theory under asymmetric information, with society (the customers represented by a regulator) as the principal and the utility (and its manager) as the agent. According to Baldwin and Cave (1999), in the case of state-owned utilities, public managers had substantial discretion over expenditure and had little personal interest in good financial results. They were, thus, tempted to gratify their own preferences, which often ran to substantial expenditure on gold plating the engineering and design aspects of capital.

Hinds, Sanchez, and Schap (1991) emphasized that private firms belong to private shareholders who have an incentive to incur the costs of monitoring the actions

of management, according to the property theory. Concentrated ownership makes monitoring of management economical, and close monitoring induces managers to maximize the wealth of the private owners. In the case of private firms, Parker and Kirkpatrick (2005) explained that in low-income countries, an international company provides commonly privatized services. Thus, one could expect the nature of the ownership of assets in developing countries to complicate the operation of a price cap, because with price-cap regulation, the utility with a given price cap will be able to make extra profits by degrading the quality of service.

Hinds et al. (1991) claimed that a public enterprise consists of organizations owned and controlled by the government. Centeno and Serra (2007) categorized the public enterprises of Latin America as follows: (a) controlled, (b) influenced, and (c) independent. *Controlled* involves public firms making decisions based on the wishes of politicians who have an interest in sharing the benefits of the utility with their party and consumers to gain votes. *Influenced* involves public firms basing their decisions on the technical criteria of board members who are restricted by public rules and regulations. *Independent* involves firms belonging to the government, but public rules and regulations do not influence managerial decisions.

Centeno and Serra (2007) further stated the main electric distribution utilities in Latin America belong to European and American investors and a small percentage of national or regional investors, whose culture influences decision making. The basis of European investors' behaviour is preserving a good reputation while American investors' preference is to recuperate their investments in the short term. National or regional investors, who generally do not have the background and knowledge of the distribution business, are more aggressive at cutting costs. Finally, taking into account the technical report of the CIER (2007), Table 3 indicates the type of ownership (private and state owned or municipal) of the electric distribution utilities in Latin American countries.

The decision-making behaviour of the electric distribution utility to promote the quality of service will develop according to the type of ownership (private or public). Hart et al. (1997) argued that public enterprises would be superior to private firms especially when full specification of the quality of service was not available. However, according to the principal-agent theory, public utility will respond to the official representatives of the government and so could expend more in providing a better quality of service while the private utility controlled by a private manager will maximize its profits. In this sense, one could argue that private firms under the regulation of incentives have high incentives to cut costs, which may result in a reduction in the quality of service.

Thus, the ownership of the utility constitutes a relevant factor in the economic behaviour of the electric distribu-



Table 3  
*Types of Ownership in Latin American Utilities*

Type of ownership	Countries	No. electric distribution utilities
Private	Argentina, Bolivia, Brazil, Chile, Colombia, El Salvador, Guatemala, Panama, & Peru	68
State owned	Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Honduras, Paraguay, Peru, Uruguay, & Venezuela	60

tion utilities in Latin America. To test the real implications of ownership, the study will involve categorizing the public and private utilities depending on the influence of participation and control of the government in decision making and depending on the origin of the investor. Because the reform in many Latin American countries remains incomplete, Latin America is a natural laboratory to test the influence of ownership on the quality of service, which may aid regulators and policymakers in improving regulation policies.

## Conclusion

One of the major outputs of the electric industry is the quality of service. Because the electric distribution activity occurs under natural monopoly, regulation is required to guarantee the investors a reasonable payment for their investments and to guarantee the consumers fair price, quality of service, and access. The quality of service is a hidden cost of privatization due to the lack of a quality-of-service policy. An important question concerns why the quality of service has deteriorated. The answer may be evident in the theoretical arguments of Spence (1975), Sheshinski (1976), and Kidokoro (2002), who claimed that the schemes of regulation influence the level of quality of service of the firms. Few researchers have conducted empirical studies assessing the quality of service in the United States in the telecommunication sector, and only one study concerns the electric industry (Ai & Sappington, 1998; Clements, 2001; Ter-Martirosyan, 2003). Because the institutional endowment of developed countries and their regulatory bodies have more experience in regulation, the behaviour of the utilities in both developed and developing countries could show different outcomes. Before the 1990s, the utilities in developed countries provided a good quality of service due to the use of RORR, while the utilities in developing countries had not used any regulation scheme due to government ownership. Regulation by incentives promotes cost cutting, which impacts adversely on the quality of service (Spence, 1975; Sheshinski, 1976; Kidokoro, 2002). The type of ownership is another important factor that influences decision making on investments and expenditures for improving the quality of service. According to the theory of contracts, a public firm could be more efficient than a

private firm should there exist an incomplete contract. The private utility in its purpose of being more profitable would have the incentive to cut costs, so affecting the quality of service not specified in the contract with the government. The proposed study of how the factors of regulation, monitoring, and ownership influence the quality of service of Latin American electric distribution utilities may provide regulators and policymakers with knowledge to improve the regulation policies to support the credibility and sustainability of the reform (privatization).

## CHAPTER 3: METHODOLOGY

The purpose of this study will be to determine the influence that regulation regimes, monitoring, and ownership exert on the level of quality of service provided by electric distribution utilities in Latin America. Chapter 3 will include an explanation of the development of a research design to reach the objective of the study. Descriptions of the population and the sample will appear in the chapter. Finally, the chapter will involve examining the instrument, data analysis, and validity and reliability of the research.

### Research Design

A quantitative paradigm will form the methodology for the study because the aim of the proposed research will be to evaluate empirically the effect that regulation schemes, monitoring, and ownership have on the level of quality of service. The main reason for selecting a quantitative paradigm is that measurement of the independent variable, denominated the quality of service, is numerical through the standardized System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) (Burke, 1994). This method will aid in avoiding the soft factors of quality of service based on perceptions.

The study will include an econometric model with the quality of service functioning as an explicative variable. According to Ter-Martirosyan (2003), the independent variables will be both the SAIDI and the SAIFI. Ai and Sappington (1998, 2002) and Ter-Martirosyan (2003) emphasized that researchers should consider the explicative variables of capital, labor, and demand of the electric distribution utility. Thus, this study will involve

constructing an improved econometric model to consider the relation between the quality of service and the economical and structural factors (electric installations, labor, and demand) and the political and institutional variables (regulatory scheme, mechanism of monitoring, and type of ownership). Figure 2 illustrates the econometric model.

Figure 2. Econometric model.

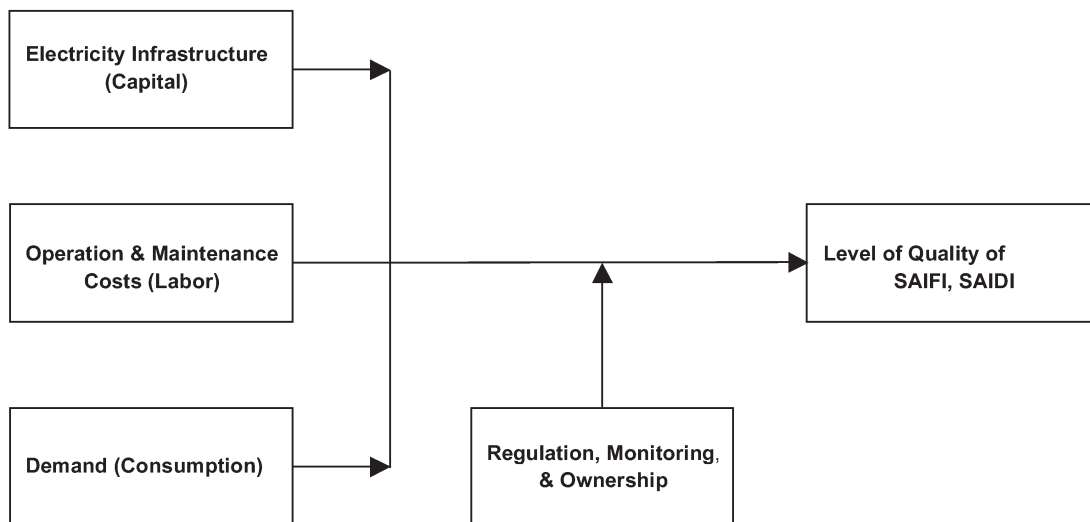


Table 4  
General Description of Econometric Model Variables

Variable	Type	Definition
Quality of service (SAIFI)	Dependent	SAIFI measures the degree of continuity of the electric service
Quality of service (SAIDI)	Dependent	SAIDI measures the time in which the utility recovers the electric service
Electric distribution installations	Independent (continuous)	Length of aerial networks, length of underground networks, number of substations, number of switches, assets
Operation & maintenance cost	Independent (continuous)	US\$ per year/km
Electric distribution market	Independent (continuous)	No. of clients, sales of energy MWh, amount of sales US\$ M
Type of regulation scheme	Independent (dummy)	1 = Price cap
Type of regulation scheme	Independent (dummy)	1 = Model firm (price cap + yardstick)
Type of quality-of-service monitoring	Independent (index)	0 = Low-powered monitoring 1 = Medium-powered monitoring 2 = High-powered monitoring
Type of ownership	Independent (dummy)	1 = SOE—Controlled
Type of ownership	Independent (dummy)	1 = SOE—Influenced
Type of ownership	Independent (dummy)	1 = SOE—Independent

Table 4 shows each dependent, independent, and dummy variable. The independent variables have been improved to reflect the effect of the electric installations on the quality of service accurately. In this model, the increment of fixed assets per year will represent the investments for the improvement of the existent installations. In addition, the model will include the number of switches

because this is a main element that determines the reliability of the electric distribution systems (Brown, 2002; Gönen, 1986). Furthermore, the operation and maintenance costs will function as an independent variable because low costs correlate with a low quality of service.

The electric distribution industry is a capital-intensive business, which involves long-living assets. This long-term characteristic reflects in the time lag between cost decision and quality outcome (Ajodhia & Hakvoort, 2005). A technique is required to manage this special feature, which mixes the cross-sectional data with the time-series data to capture the effect of the time lag (Greene, 2000). Consequently, in the proposed study, a panel data technique will permit the evaluation of the variables and factors, which determine the level of quality of service for a number of firms over  $i$  and  $t$  periods. The study will include 128 electric distribution utilities from 16 countries in Latin America over a period of 5 years.

Consideration of dummy variables will capture the diversity of the political and institutional variables. In this regard, the referenced dummy variables for testing the corresponding hypothesis will be rate-of-return regulation (RORR) scheme, type of monitoring and private firm ownership. Taking into account the listed variables

in Table 5, two economic regressions for the SAIDI and SAIFI dependent variables will constitute the econometric model. Both of the economic regressions will be explained by the same independent variables, as seen in Equations 1 and 2:

$$\begin{aligned} SAIDI_{it} = & \beta_0 + \beta_1 Kmaereal_{it} + \beta_2 Kmunderg_{it} + \beta_3 Switches_{it} + \beta_4 OM_{it} \\ & + \beta_5 Fassets_{it} + \beta_6 Kwh_{it} + \beta_7 Dreg\_pcap_{it} + \beta_8 Dreg\_model_{it} + \beta_9 Dmonit_{it} \\ & + \beta_{10} Downer\_soecontr_{it} + \beta_{11} Downer\_soeinfl_{it} + \beta_{12} Downer\_soeind_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

$$\begin{aligned} SAIFI_{it} = & \beta_0 + \beta_1 Kmaereal_{it} + \beta_2 Kmunderg_{it} + \beta_3 Switches_{it} + \beta_4 OM_{it} \\ & + \beta_5 Fassets_{it} + \beta_6 Kwh_{it} + \beta_7 Dreg\_pcap_{it} + \beta_8 Dreg\_model_{it} + \beta_9 Dmonit_{it} \\ & + \beta_{10} Downer\_soecontr_{it} + \beta_{11} Downer\_soeinfl_{it} + \beta_{12} Downer\_soeind_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

Both dependent variables are annually measured indices. Similarly, the independent variables will be ratios per year, which will help to homogenize the sample. Following the heuristic model of the electric distribution systems and the economic theory, the coefficients of the independent variables should reflect the signs presented in Tables 5 and 6.

Table 5 illustrates the expected relations between the

Table 5

*Expected Relation between Economical and Structural Factors and the Quality of Service*

Variable	SAIDI	SAIFI	Quality
Kmaereal	Positive (+)	Positive (+)	Negative (-)
Kmunderg	Positive (+)	Positive (+)	Negative (-)
Switches	Negative (-)	Negative (-)	Positive (+)
OM	Negative (-)	Negative (-)	Positive (+)
Fassets	Negative (-)	Negative (-)	Positive (+)
kWh	Negative (-)	Negative (-)	Positive (+)

Table 6

*Expected Relation between Political and Institutional Variables and Quality of Service*

Variable	SAIDI	SAIFI	Quality
Dreg_pcap	Positive (+)	Positive (+)	Negative (-)
Dreg_model	Positive (+)	Positive (+)	Negative (-)
Dmonit	Negative (-)	Negative (-)	Positive (+)
Downer_pri	Positive (+)	Positive (+)	Negative (-)
Downer_soe_contr	Negative (-)	Negative (-)	Positive (+)
Downer_soe_infl	Negative (-)	Negative (-)	Positive (+)
Downer_soe_indep	Negative (-)	Negative (-)	Positive (+)

control variables and the economical and structural factors of the electric distribution system. The positive (+) sign represents an increment of the SAIDI and SAIFI indices which influences the quality of service negatively. The negative (-) sign represents a diminishing of the SAIDI and SAIFI indices representing an improvement in the quality of service

To clarify the hypotheses to be tested, Table 6 presents the expected relationships between the institutional and political variables and the quality of service.

## Appropriateness of Design

Because the sample data include the characteristics of both cross-sectional and time-series information, a panel data technique may be appropriate. The panel data allow for the control of the heterogeneity of the electric distribution utilities and allow for the capture of the dynamics of the data (Greene, 2000; Verbeek, 2000; Wooldridge, 2001). The data set enables one to quantify the effect of the variables included in the hypotheses, such as the independent variables, which influence the quality of service.

The empirical equation under consideration will be the following:

$$Y_{it} = \alpha_j + \beta_0 + \sum_{k=2}^K \beta_k X_{kit} + \varepsilon_{it} \quad \varepsilon_{it} \equiv IID(0, \sigma_\varepsilon^2)$$

In the equation,  $\alpha_j$  represents fixed individual effects for the individual  $j$ ;  $\beta_k$  represents the coefficients of the common slope for the entire population;  $y_{it}$  represents the dependent variables SAIDI and SAIFI for each utility  $i$  in period  $t$ ;  $x_{it}$  represents the independent variables of the level of quality of service;  $K$ ' variables exist where  $K' = K-1$ ; and  $\varepsilon_{it}$  represents the model errors.

The estimation technique selected for the analysis will be a model based on panel data (Greene, 2000; Verbeek, 2000; Wooldridge, 2001). Three models of panel data will be available for selection: (a) pooled model with least square estimation, where  $\alpha_j = 0$ ; (b) fixed-effects model with the within estimator, where  $\alpha_j$  is constant terms that vary across individuals; and (c) random-effects model with generalized least square estimators, where  $\alpha_j$  is a random term with the following distribution:  $\alpha_j \equiv IID(0, \sigma_\alpha^2)$ . The random-effects model is the most efficient model but is only consistent when  $\alpha_j$  and the explanatory variables are not correlated. The fixed-effects model will not be appropriate in the context of this research because it eliminates anything that is time invariant from the estimation. Thus, the random-effect model will be more appropriate for this research with an interest in the political and institutional variables that do not vary throughout the considered period.

A Hausman test will aid in testing the validity of the random-effects model. This test involves examining the

null hypothesis that  $\alpha_j$  and the explanatory variables are not correlated through the comparison of results of fixed effects and random effects. A fixed effect is always consistent, which means that the estimated value is on average equal to the true effect. Efficiency involves minimizing the variance of the estimator.

## Research Questions

The aim of the research will be to determine how regulation schemes, monitoring, and ownership affect the quality of service provided by electric distribution utilities in Latin America. For this purpose, the following research questions will guide the study:

1. How do the regulation schemes affect the quality of service provided by the electric distribution utilities in Latin America?
2. How does the monitoring mechanism affect the quality of service provided by the electric distribution utilities in Latin America?
3. How does ownership affect the quality of service provided by the electric distribution utilities in Latin America?

## Hypotheses

The regulation regimes influence the quality of service. Thus, the study will involve testing the following hypotheses:

$H_1$ : The RORR regime favors a better quality of service than the price-cap regime.

$H_2$ : The RORR regime favors a better quality of service than the model-firm regulation.

The degree of monitoring influences the quality of service. Thus, the study will involve testing the following hypothesis:

$H_3$ : The higher the degree of monitoring, the better the quality of service.

The type of ownership influences the level of quality of service provided by the electric distribution utilities. Thus, the study will involve testing the following hypotheses:

$H_4$ : The private firm harms the quality of service in comparison with the politically controlled public firm.

$H_5$ : The private firm harms the quality of service in comparison with the influenced public firm.

$H_6$ : The private firm harms the quality of service in comparison with the independent public firm.

## Population

The study will include the electric distribution utilities of 16 countries in Latin America: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela. The cited population in-

cludes 128 utilities with different schemes of regulation, different mechanisms of monitoring, and different types of ownership. The distribution of the firms according to their regulation schemes is as follows: RORR (25%), price-cap regulation (60%), and model-firm regulation (15%). The segmentation of the groups according to their mechanisms of monitoring is as follows: high-powered monitoring (22%), medium-powered monitoring (53%), and low-powered monitoring (25%). The composition according to the type of ownership is as follows: private (53%) and state-owned (47%).

### **Informed Consent**

The informed consent aims to indicate that the participant has decided to take part in the research of his/her own free will. The consent form describes the research and its nature and also certifies the attesting to the participant's consent. Thus, the representatives of the utilities will receive the informed consent format, which will explain the aim of the research and give the utilities the confidence to collaborate and participate in the research.

### **Sampling Frame**

Data collection will involve a structured questionnaire to collect the technical, economical, and market information of all the electric distribution utilities in Latin America. It is important to point out that Mexico is the only country that is excluded from the sample. The data will correspond to the period 2002 to 2006 because regulators and electric utilities have recorded information regarding the quality of service only since the beginning of the year 2000.

### **Confidentiality**

Coding of the collected information will occur. The identification of the electric distribution utilities will only be evident for internal use during the processing of data. The final report will appear in coded form.

### **Geographic Location**

The study will cover 16 countries in Latin America: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela. This means all the countries that are located throughout Central and South America. However, the countries located in the Caribbean are not taken into account.

### **Instrumentation**

A questionnaire has been designed to gather the information needed for the econometric model. The instrument

will aid in collecting the following information: market, technical, quality-of-service, financial and cost, regulatory and monitoring, and ownership data. The instrument will also help to set the relevant indices of the distribution activities. Designing the questionnaire involved following the recommendations of simplicity, clarity in the definition of the variables, and its quantitative measurement.

### **Data Collection**

The electric distribution utilities; regulators; and the association of the electric distribution utilities of Argentina, Brazil, Chile, Colombia, and Peru will complete the designed questionnaire to provide the data for this study. In addition, data collection will involve accessing the information published on the Web sites of the electric distribution utilities; regulators; and organizations, such as the Organización Latinoamericana de Energía (OLADE) and the Comisión de Integración Energética Regional (CIER). The recollection through various sources will permit a revision of the reliability of the reported information to guarantee its validity.

### **Data Analysis**

Data analysis will include the following procedures: First, analysis of the descriptive statistics and the correlation of all the variables of the model will occur. The analysis will provide useful information about the mean values and variability and will indicate possible multicollinearity problems. Second, estimation of Equations 1 and 2 will occur using Ordinary Least Squares (OLS), within estimator, and Generalized Least Squares (GLS) (Greene, 2000; Verbeek, 2000; Wooldridge, 2001). A discussion of the most suitable estimator will result. Analysis of the outcomes of all the estimations will include taking into account the theoretical framework previously stated and the formulated hypotheses. Finally, the standard errors will be adjusted to address any heteroscedasticity problem.

### **Validity and Reliability**

The validity and reliability of the estimation require using estimators that are consistent and as efficient as possible. The hypothesis to be tested will be confirmed in the case of the coefficients associated with the relevant variables (political and institutional factors) being statistically different from zero (using the standard p values of 10, 5, and 1%). The standard t test, F test, and Hausman test will aid in guaranteeing the reliability of the outcomes. For processing and testing the data and the model STATA software will be used.

Guaranteeing the validity of this study will involve verifying the collected data through cross-checking the different sources of information (utilities, regulators, and

other nongovernmental organizations). The information will be registered and filed with a code.

## Summary

The panel data econometric model adopted for this study will enable the combination of cross-sectional and time-series information, which is necessary to assess the influence that the regulation scheme, monitoring mechanism, and ownership have on the quality of service provided by the electric distribution utilities. The aim of the proposed model will be to measure the effects that the independent variables have on the quality of service. For this reason, the previous models elaborated by Ai and Sappington (1998, 2002) and Ter-Martirosyan (2003) have been reviewed in light of both the electric distribution reliability system and economic regulation theories. According to this revision, the inclusion of the following variables will improve the model: number of switches, investments per reinforcement of the existent capacity, mechanisms of regulation, monitoring, and types of ownership. Because this empirical study will involve the electric distribution utilities of Latin America, the model and the outcomes of this study could be generalizable in other similar regions.

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## Footnotes

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