REGULATING THE ELECTRICITY SECTOR IN LATIN AMERICA

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Abstract

During the past decade most Latin American countries reformed and liberalized their electric sectors. This paper examines these reforms, providing a critical examination of the effects. Late reformers learnt from the experience of earlier reforming countries, and in particular from the Chilean experience. This evolutionary process has meant less regulation of segments that are or can be made to be competitive (generation and commercial services) and more regulation of the non-competitive sectors (transmission and distribution) combined with the vertical disintegration of competitive and noncompetitive segments of the industry. Nevertheless, a market approach to generation must worry about the possibility of strategic behavior by generating companies. Some open questions remain, for example, how to solve the problem of the expansion of the transmission system and how to strike a balance between a regulator that has some freedom of action to react to unforeseen events, and the corresponding fear of regulatory takings.

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1. Introduction

Latin American countries began reforming their electricity sectors in the early 1980s. Countries experimented with a wide variety of systems, ranging from early administered systems to recent systems which give the market a broader role. Regulatory reform was undertaken before privatization, so issues of regulatory takings did not arise at first. Reforming Latin America's electricity sector occurred within a process of learning by watching, and regulations evolved as reform has spread over the region. This paper describes and evaluates the reforms and points to ways in which Latin American countries can further improve the functioning and regulation of the electricity sector.

In general terms, the privatization-cum-regulation of the region's electricity sectors was successful: privatized firms increased their efficiency and coverage substantially. But these productivity gains were passed on to consumers only in those cases featuring competition, which reinforces the idea that competition is the ideal regulator. The main policy lesson that can be derived from the Latin American experience with privatized electricity sectors is that countries should aim to establish conditions that lead to the broadest possible scope for competition.

Later reformers learned from the experience of countries that deregulated earlier in both Latin America and the rest of the world. This process has resulted in three different generations of regulatory reforms. The first stage, which was restricted to Chile, started in the late 1970s with the development of a new legislation, which was introduced in 1982, and ended with the privatization of the major electric firms between 1986 and 1989. Chile's neighbors carried out the second round of reforms in the first half of the 1990s, an example of regulatory diffusion. The third generation took place during the second half of the decade, and it included most of the remaining Latin American countries. Understandably, reform designers attempted to extend the scope and depth of competition at each regulatory stage. Moreover, the speed at which reforms were accomplished accelerated. The changes made in Argentina from 1990 to 1992 took a whole decade to achieve in Chile.

Introducing competition in the wholesale contract market was a cornerstone of the Chilean reform, and in fact this is the only free market in the system. This is the market in which power generation companies (gencos) and large customers and distribution companies (discos) establish long-

term supply contracts**.** Since participants in this market are located in different geographic areas, the unbundling of transmission services was a requisite for wholesale competition. Thus the principle of open access to the transmission network was introduced, and gencos and the transmission company (transco) were allowed to freely negotiate transmission fees. The second major innovation of the Chilean system was that investment in generation was left to market forces. As the expansion of the demand for electricity leads to higher prices, the profitability of developing new projects increases. Existing enterprises or potential entrants will invest in generation whenever a project has a return on capital that is conmensurate with the sector's risk.

Although the market for large customers was completely deregulated, retail services remained highly regulated. Discos are required to provide service within their (nonexclusive) franchise areas at a regulated retail price. This price has two components: (1) the regulated price at which discos purchase energy and power from generators and (2) the value added of distribution (VAD), which remunerates services provided by the disco. Using incentive regulation to compute the VAD was Chile's third major regulatory innovation. Prices are set in such a way that, in principle, an efficient disco would attain a predetermined rate of return.

Was privatization successful? Chilean companies increased their capacity substantially: annual generation more than doubled from 1990 to 1998. Privatization also increased the productivity of utilities by cutting energy losses by more than half to 8.3 percent in 1997, by doubling labor productivity in distribution, and by tripling energy generation by worker in the largest genco. Although privatized companies became substantially more efficient, however, these gains were only transferred to customers in areas characterized by competition. In the main market, the regulated wholesale price of electrical energy fell by 37.4 percent, and technological change stranded (that is, rendered uneconomical) a large fraction of existing thermoelectric plants. In contrast, the final price to customers did not fall to reflect the huge productivity gains that were achieved after privatization. Between 1987 and 1998 the regulated price to consumers fell by only 17 percent. This situation led to spectacular increases in the profit rates of distribution companies: the rate of return of the largest Disco rose from 10.4 percent to 35 percent in this period. These profit rates are striking considering the low risks involved in monopoly distribution.

Not surprisingly, the second generation of electric utility reforms was characterized by the introduction of pro-competitive regulations. The main goal was to increase competition in the supply of

energy to large customers, and many changes were introduced to this end. Governments paid more attention to the restructuring of the sector both before and after privatization. Horizontal unbundling helped ensure competition in generation, and some countries employed yardstick competition to regulate distribution. To facilitate competition in the wholesale market, transmission fees, as well as the charge for local distribution services for large customers, were set by either the regulator or the pool operator. Vertical integration was either prohibited outright or limited. The threshold for being considered a large client was reduced**.** The spot market and membership in the pool operator, who commands the operation of plants, began to include large customers (including distribution companies) and transmission companies, whereas previously it was restricted to generators. Moreover, instead of regulating the price at which discos purchased electricity, some Latin American countries instituted a system in which discos put their energy requirements out to tender among all generating firms.

Regulations became more flexible, bestowing more discretion on regulators. Regulations also began to incorporate quality issues, and fines for bad service were increased considerably. The process of setting the regulated price became more transparent. In Chile regulators are not allowed to publish the information used in rate-setting except to the regulated firms, which prevents the demand side of the market from counteracting the lobbying pressure of regulated firms; in Argentina, in contrast, public hearings became an important tool of the regulatory process. All these changes made the markets in Argentina considerably more competitive than in Chile.

The third generation of regulatory reform, which is still underway, has tended to further deregulate those segments of the electricity sector that are competitive or likely to become competitive. Two major changes characterize this third reform stage: the introduction of retail competition and the liberalization of the spot market for energy**.**

Retail competition requires a new participant in the market: the energy broker. The introduction of this new participant enables small customers to buy electricity from competing brokers. The brokers, in turn, purchase electricity in the wholesale market and pay a regulated fee to transcos and discos for the use of their infrastructure. Since unbundling distribution and commercialization activities facilitates competition in the latter, some Latin American countries exclude discos from the retail market. Hence distributors are restricted to providing “wire” services. Other countries regulate the participation of discos in the retail market in order to avoid unfair competition. Although retail competition is too new to

evaluate its impact in the region, it does reduce the number of activities that need to be regulated. Moreover, brokers form a lobbying group with a clear interest in the proper regulation of discos.

The second characteristic of this third generation is liberalization of the spot market. Gencos are able to make price and quantity bids which the pool operator uses to build a supply curve for energy. This supply curve is used to command the operations (dispatch) of generating plants, replacing the merit-order system based on operational costs, which was used by earlier reform countries.[1] In these countries, the marginal cost estimates are a major source of disputes among generators and between the generators and the pool operator. An important advantage of the bidding system used by Colombia is that it leads to simpler operating rules in the pool, since offer prices represent most of the information required to perform the pool dispatch. The system's major difficulty is the possibility of strategic behavior by power generators, which is a real concern in bid markets with few participants.

New regulatory reforms will probably develop as new challenges appear. First, the countries that privatized earlier will have to modernize their regulations, which are becoming obsolete as new reforms in developing and developed countries signal the way to freer, more efficiently regulated markets. Moreover, increases in cross-border electricity transactions will promote regulatory convergence in the region, as it will be difficult to coordinate operations when partner countries have different regulatory frameworks. Second, the appearance of multi-utilities and environmental restrictions will require changes in current regulations. Third, the transmission and distribution monopoly may be weakened as technology lowers the minimum size of an efficient generation plant.

What is in store for the future? Though there are several approaches to designing regulatory frameworks for the electricity sector, the system used by Nordic countries seems to be the most successful. In that internationally integrated market, gencos have no obligation to supply energy to the pool and can establish physical, long-term contracts with customers. An active market for standardized energy derivatives has arisen. A day-ahead and a two-hour-ahead bidding market for buyers and sellers settles a major fraction of the remaining trades, leaving the spot (or "power regulation") market only for the last-minute small adjustments needed by the systems operator; this reduces the importance of a

1. Developed countries have established sophisticated energy markets which bid by buyers, thus obtaining a demand curve. Moreover, they have long-term forward contracts, derivatives, and sometimes decentralized markets. See Millan (2000); Wilson (1999).

market in which market power seems easy to exercise. Ancillary services that provide security to the system have their own markets. Finally, transmission constraints due to weak links between regions are reduced by raising prices in importing areas and reducing them in exporting areas. Demand and supply responses reduce the energy flows though these links, thus providing signals to invest in generation or transmission in areas with high prices.

The next section describes the regulation of energy generation in Latin America. This is followed by an analysis of transmission and then of distribution. The fifth section describes regulatory compliance and governance problems in Latin America while the final section concludes with observations on the future of regulatory reform.

2. Energy Generation

This section examines the regulation of wholesale electricity markets in Latin America. We simplify the discussion by assuming that power plants and consumers, the two participants in the wholesale market, are located at the same spot; transmission and distribution activities are examined in the next two sections. Legislation usually allows only large buyers to participate in the wholesale market, such that consumers can be divided into large consumers who buy for their own consumption and distribution companies or commercialization firms, which buy in order to sell to small consumers.

Two types of transactions are brokered in the wholesale market: long-term supply contracts and spot sales. Given the economic impossibility of storing electricity, supply must meet demand at all times. Thus a spot market for electricity requires, at the least, a central planning agency (or pool operator) that plans the actual operation (or dispatch) of generating plants in the very short term (every hour is usual and sometimes shorter periods are used).[2] Latin American legislation commands the pool operator to select the dispatch order that minimizes short-term costs, independently of existing long-term supply contracts.[3] The pool operator ranks the price offers of generating companies and user demands. Next it

2. Large countries feature several organized mechanisms which are in constant communication if the systems are interconnected. The pool operator is also responsible for system integrity and thus for responses to unforeseen spikes in supply or demand.

3. El Salvador and Brazil are the exceptions. In these countries the pool operator dispatches only noncontracted energy. Generators and other operators in the pool are required to submit bids on price and available capacity

computes the price—the so-called spot price—that clears the market. The spot price of energy is thus the offer price of the last-dispatched (and most expensive) plant in operation, and demand is satisfied by those plants that bid a price less than or equal to the spot price.

In the first countries in the region to deregulate their electricity markets, a plant's offer price is determined by law to be the short-term marginal cost. This means that the pool is not really a market, since gencos are not free to set their offer price. If short term marginal costs are computed correctly, however, plants are always willing to operate when mandated to do so. In countries that have deregulated their electric systems more recently, gencos are free to make bids on quantities and price.[4] Since dispatch is independent of existing contracts, gencos must trade energy. Firms that generate less energy than required to serve their contracts are net buyers of energy in the pool; they must settle accounts with net sellers using the spot price. In Chile all users are required to have contracts, so the spot market is used only for transactions among gencos (though contracts between gencos and clients can use the spot price as a reference). In Bolivia and Argentina, most users buy in the spot markets, and long-term contracts are uncommon.

Large users are always allowed to establish long-term contracts with gencos or to buy directly in the spot market. Special rules apply for disco transactions. Countries that privatized their systems early usually regulate the retail price of electricity. Later reformers require discos to contract electricity through competitive bidding, and they regulate the VAD.

2.1. Power Plant Dispatch

The pool operator must follow rules when dispatching power plants. As mentioned above, Latin American countries that have reformed their electricity sectors have followed two alternative approaches to pool dispatch. A first group of countries uses merit-order dispatch, in which the pool operator ranks plants on the basis of short-term marginal operating costs and dispatches those with lower costs first. Bolivia, Chile and Peru use this system.[5] Colombia followed the United Kingdom in

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after physically fulfilling contracts.

[4] Even in those countries, the demand side of the market does not participate in thre bidding process, that is, demand is assumed to be inelastic when computing the spot price.

[5]. Peru is considering introducing a bidding system for thermal power plants (not for hydraulic power).

adopting a different approach.[6] Gencos make bids on price and available capacity, information that is used by the pool operator to build a least-cost dispatch function for the next day.[7] Argentina uses an intermediate approach: firms "offer" marginal costs for periods of six months.

In a world of perfect information, no uncertainty, and perfect competition, these systems would lead to the same efficient dispatch order. However, in the real world of imperfect competition, uncertainty, asymmetric information and lobbying, these systems may work differently, resulting in advantages and disadvantages. The main advantage of using short-term marginal costs to determine dispatch is that it reduces the possibility of short term strategic behavior on the part of gencos, which is a real concern for spot markets with bidding and few participants.[8] The same type of conduct has also been observed in the United Kingdom.[9] The danger of noncompetitive behavior would be higher in Bolivia and specially Chile, which have few gencos.

On the downside, the use of marginal costs requires that pool operators play a prominent role in determining short-term marginal costs, especially in systems with an important hydroelectric component. The determination of the marginal cost thus becomes a major source of disputes among the gencos within the pool and between the gencos and the regulator. It also becomes attractive for gencos to lobby the regulator that oversees the pool operator to bend the rules in their favor. Disputes may arise over the relevant components of the marginal cost and over the price of inputs used to generate electricity. For instance, determining the appropriate price of an input such as coal or allowing the use of environmentally polluting sources of energy may become major issues, as they can alter the order of dispatch.

Most South American countries are heavily dependent on hydroelectric power for their base-line consumption. In an average year, the Andean countries and Brazil satisfy about 80 percent of their energy needs through hydroelectricity. Even Venezuela, with its abundant oil resources, derives more than 60 percent of its energy from hydroelectricity.[10] This dependence leads to high supply uncertainty

6. For U.K. deregulation, see Green (1998).
7. In practice, about a third of the plants in Colombia operate out of merit order due to transmission constraints and other problems. See Rudnick (1998).
8. Stacchetti (1999); Rudnick (1998).
9. See Wolfram (1998); Newbery (1998).
10. Argentina is the only country in South America in which thermoelectricity is dominant.

caused by variations in annual rainfall. The problem has different ramifications for the two basic types of hydroelectric plants. The first type of plant does not have access to a reservoir with significant storage capacity, so its power generation depends directly on the current flow of water, which cannot be regulated. In the Andean countries, river flow levels vary substantially over the year and between years, which means that the power generation from these plants is subject to significant uncertainty. On the other hand, their operation is straightforward, since they always run at maximum capacity given the flow of available water: they are always the base plants in the system.

The second type of plant is connected to a reservoir. Water accumulated in reservoirs can either be used today to displace other sources of electric power or it can be stored for future use. The efficient operation of these plants therefore depends on the option price of stored water. The option price of water, in turn, depends on the expectation of future rainfall (which affects both the levels of the reservoirs and the amount of energy produced by hydro plants with no reservoirs), the current levels of the reservoirs, plans for future power plants, and on the expected future marginal costs of thermal plants.[11] Pool operators that use marginal cost dispatch have developed optimal control programs with various degrees of sophistication to determine the option price of water. The parameters that feed the program need to be estimated, which adds a degree of uncertainty to the determination of the marginal costs of these plants. (For instance, the probability distribution of rainfall is based on historical records which may be biased by changes in the weather pattern) Note how this complex process is intertwined with the determination of the marginal costs of the thermal power plants. The numerous parameters that are necessary for running the model are a source of conflict between thermoelectric and hydroelectric generators and between these and the regulator that oversees the pool operator.

In general, it appears that the bidding system used in Colombia leads to simpler rules of operation in the pool, since most of the information necessary to organize the dispatch are the offer prices and quantities. The main restrictions the pool operator faces are transmission and integer constraints that must be considered in its least-cost dispatch function.[12] Simplicity is thus a big advantage

11. In especially rainy years, when reservoirs are full and letting off water and when all energy is produced by hydroelectric plants, the marginal cost of energy is zero.

12. In Colombia, following the U.K. example, all bids are based on delivery at a single geographic point, thus sacrificing spatial differences.

of bidding schemes for pool operation.[13] Nevertheless, a significant number of Latin American countries opted for schemes which use short-term marginal costs to determine dispatch. In the early 1980s, Chile was the first country to reform its electricity sector, in what may be seen as a first-generation reform. The designers of Chile's reform were engineers who were heavily influenced by the system used in France. [14] The introduction of the pool as the place where competing private generators coordinated their supply activities was a revolutionary change. This reform was probably tempered by the worldwide lack of experience with such an approach and by a misunderstanding of markets (by present standards) that led to an "engineering" approach to reform.[15] When other countries in the region (namely, Argentina, Bolivia, and Peru) reformed their own systems, they turned in part to the Chilean experience and used Chilean consultants, leading to (improved) second-generation systems that still used the same basic dispatch scheme. Colombia is an example of a third-generation reform that displays more confidence in markets and that has learned from the U.K. experience, while El Salvador and Brazil appear to represent a fourth generation of reform, in which the pool operator is concerned only with the surplus, noncontract market for energy.

2.2. Incentives for Investment and Security

Perhaps the biggest revolution introduced by reformers of the electricity sector was the notion that the profitability of the market would determine investment in generating capacity. This idea, which now seems obvious, was unprecedented in Latin America, where most generating companies were owned by the state and followed government directives in investment (using a systems engineering approach, if that). Under the new approach, high prices for electricity provide a signal to attract

13. This statement must be qualified, since many alternative bidding systems are currently in use, with various degrees of complexity.
14. The concept of marginal cost pricing was first designed for the state-owned Electricité de France. See Rudnik (1998).
15. The distrust of private markets for utilities was also widespread in developed countries at the time.

investment until the profitability of the industry equals that of other activities facing comparable risks. Conversely, if electricity prices are too low, investment will not occur, and the normal growth of the national economy will raise demand and prices until it becomes profitable to build new plants.

As mentioned above, the spot price of energy pays for the short-run marginal cost of generation. Energy capacity in the spot market must therefore be rewarded in order to maintain plants that are only used in dry years and that do not earn inframarginal profits to pay for capital costs. For efficiency, this reward should be equivalent to the marginal capacity cost (see appendix).[16] In most Latin American countries (including Colombia), the spot price of power is the annuity that would pay for the cheapest possible addition to capacity, that is, an open cycle gas turbine. The spot price of power must be paid to owners of installed generating capacity, but this requires additional finesse. Since hydroelectric plants might not be able to provide much power in dry years, when energy is scarce, it would be inappropriate to pay them for all of their capacity. Hydropower plants therefore receive payment only for the energy they are able to supply in dry years, which is called firm power (*potencia firme*). Similarly, the firm capacity of thermal plants is computed considering their normal failure rates. In Chile and in Peru power payments are determined *ex ante*. Those gencos that have supply contracts exceeding their firm capacity must buy power (that is, spare capacity) *ex ante* from other generators to cover the difference.[17] This system of payment for capacity ensures that there are spare plants which remain inactive most of the time but which will still be available to produce energy in dry years.

Argentina introduced a different system to reward capacity, in which plants are paid as a function of the energy supplied over a prespecified period. This scheme has caused distortions in the spot market, as firms are effectively paid twice for energy supplied: once as the spot market price and once as a capacity reward. Since plants offer bids on their marginal cost for six months, firms have an incentive to shave their bids in an effort to capture the power reward, which distorts the efficiency merit order.

In most countries that have reformed their electricity sectors, investment in power plants has been more than sufficient to cope with demand. For instance, in Chile investments have been made

16. Large customers' freely negotiated prices are likely to include investment costs. Moreover, they usually consist of a short-run marginal cost plus a capacity payment.

17. A similar system of payment for capacity is used in Bolivia and Colombia.

ahead of the indicative plans prepared by the government. Argentina has experienced a serious oversupply problem, which has led to low costs for consumers and low profit rates for investors. In spite of the increased investment, both Chile and Colombia have experienced supply problems in years of extreme drought—especially among regulated clients—which can be explained mainly by failures in regulation. The Colombian case is analyzed below, while the Chilean situation is taken up in the section on regulated prices.

After experiencing problems with energy restrictions during the 1992 droughts, Colombia introduced a simpler approach to dealing with droughts by placing limitations on the operations of hydroelectric plants that are dependent on stored water. The regulator decreed that during the dry season, if the level of water in the reservoirs should fall below predetermined levels, the associated power plants would be dispatched only after all other bids became insufficient to cover demand. Note however that if the market were allowed to operate freely, owners of stored water would probably internalize the future value of energy and thus would use it according to its economic value. If this were the case, there would be no need to restrict the use of stored water.

Stacchetti claims that some plants in Colombia have gained substantial market power because of the restrictions on reservoir extraction.[18] Rudnick notes that in Colombia around 35 to 40 percent of the generating capacity corresponds to out-of-merit generators (i.e., generators that operate outside the merit order), that is, those that must operate independently of their bids. These generators are constrained by "*transmission grid weaknesses (transformation restrictions, line capacity limitations and compensation requirements), minimum water storage requirements and machine inflexibilities which modify the ideal dispatch.*" Since these plants are paid based on their bids, and the operators know that they have to be dispatched irrespective of bids, they have strong market power. Rudnick estimates that the cost of these restrictions as compared to the ideal merit order was around $10 million per month in the period 1995–97. It is important to observe, however, that this amount combines the cost of "payments to dominant generators and opportunity costs to nondispatched generators," that is, it mixes the rents accruing to market power with the costs of skipping merit order.[19]

18. Stacchetti (1999).

19. Rudnick (1998).

None of the complications caused by the need to respond to large variations in available energy occur in interconnected systems with dominant thermoelectric generation, where the main problem is how to pay for security in case plants fail (a power rather than an energy failure). In these countries, some plants must run constantly at less than full capacity (a rolling reserve) just in case other plants fail, and they must be remunerated appropriately.[20] In contrast, power failures are relatively rare (excluding extremely dry conditions) in systems with an important component of hydroelectric power based on reservoirs, since the possibility of using more water to generate electricity in selected plants stabilizes the system. In these countries, the amount of water stored in reservoirs provides an indication of the possibility of future energy shortages: hence they are "energy" rather than "power" failures.

2.3. Regulated Energy Prices

As mentioned above, discos buy energy and power for their customers and pass the cost of the purchase (plus distribution and other costs) on to consumers. Early reformers regulated these prices to defend the interests of small consumers. Moreover, they feared that residential and small commercial users would be unable to deal with wide variations in the price of electricity. Hence they established pricing schemes that change slowly in response to supply conditions. Bolivia, Chile, and Peru smooth price fluctuations by determining a medium-term price of energy (three to six months) that is computed as the average of the expected values of the short-term marginal cost over a 24- to 48-month horizon. The models make projections based on different scenarios of future rainfall, which are then averaged. Computing expected prices also requires forecasting the future growth rate of demand and future capacity expansions.

Regulating the price of energy always carries the danger of populist practices, since politicians who want to score points with voters lobby for lower prices.[21] To ensure that the regulated price does not deviate

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20. In Argentina, plants must include a reserve for these events (which is thus factored into the investment decision). These reserves can be traded between plants and the exchanges are remunerated based on the difference between the spot price and the marginal cost of the least expensive plant that keeps a reserve. Colombia is planing to establish a rolling reserve market. Other countries, such as Chile, do not remunerate these services, except indirectly, through changes in the firm power weighings.

21. As in the case of the spot price of power, in most Latin American countries (including Colombia but not Argentina) the regulated price of power is the annuity that would pay for the cheapest possible addition to capacity, that is, an open cycle gas turbine. Since this is a fairly well-established price, few disputes arise between the regulator and firms in this regard, except for disputes on appropriate plant size.

too much from reality, Chile and Peru work within a price band, which is centered around the average price of contracts negotiated between generators and large customers. The width of the band is 10 percent around the reference price.[22] At the same time, gencos ~~also~~ lobby intensely to alter in their favor the parameters and other characteristics of the model used to determine the regulated price. For instance, gencos often question which costs are variable in the short run and should thus be included in the marginal cost determination of the regulated energy price. In Chile in early 1999, a genco signed a long-term contract with a gas pipeline which set the transport price and a floor on the transport volume the company was required to pay. Should the fixed part of the transport cost be considered a fixed or a variable cost? Similarly, consider the case of a vertically owned specialist port for coal, whose main use is to unload coal to its upstream owner. Should the capital costs of the port be considered part of fixed costs?[23]

Countries where hydroelectricity is the main source of power face a major difficulty in price smoothing, namely, how to reconcile the inherent variability in energy availability with an unresponsive demand induced by the fixed regulated price. If an energy shortage occurs during a drought, regulated consumers in Chile and Peru are entitled to receive compensation for reductions in consumption below their normal level at around four times the normal cost of energy.[24] This is called the outage cost, and it is usually calculated as the cost to users of an anticipated energy shortage (as opposed to an unexpected power shortage). In principle, these compensations create the correct incentives for consumers since they face the opportunity cost of energy when supply is restricted, thus leading to reduced consumption. Similarly, power companies that are net buyers under restricted supply (that is, they have contracts that exceed their generation capacity in those conditions) have incentives to make deals with large users in order to reduce the energy provided to them. Finally, compensations also creates incentives to buy from firms which have *spare (self-)* generating capacity.

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22. Note however that in Chile the majority of the free contracts are themselves indexed on the regulated price, a fact that reduces the usefulness of the price band.

23. Incidentally, Fischer, Galetovic and Serra (1999) show that given the incentives implicit in short-term marginal cost dispatch, consistency requires that any fixed payment in a supply contract be excluded from the computation of short-term marginal costs.

24. Regulated consumers have implicitly paid an insurance because the outage cost is included in some of the hydrologies that are used to compute the regulated price of energy.

In reality, the magnitude of the compensations in relation to the normal price of energy creates enormous incentives to haggle over the fulfillment of the conditions under which compensations are paid, since gencos with energy deficits are understandably unwilling to pay. In fact, gencos have never paid compensations in Chile during periods of restricted supply (namely, 1989–90 and, more recently, 1998–99). A special codicil was introduced into the law (apparently at the instigation of the main genco), restricting the payment of compensations to years no drier than those used in the modeling of the regulated price. While there is some argument as to the convenience of the codicil, a far worse problem was that the codicil did not specify the relevant price in case the limitation applied. During the energy restrictions of the Chilean crisis of 1998–99 the codicil applied. This meant that users and generators faced the standard regulated energy price, so the incentive mechanisms (driven by compensations) to increase supply and to reduce consumption described in the previous paragraph did not apply. The lack of forces driving the market to equilibrium resulted in random outages, which imposed a large cost on society. More flexibility by the regulator would have solved the problem by raising prices in order to reflect the changed availability of energy.[25]

Another problem, endemic to Argentina and Bolivia, is that gencos are unwilling to supply energy at the regulated price, that is, to make contracts with discos. In fact, there are almost no long-term contracts between discos and gencos in those two countries. In Bolivia the spot price is usually higher than the regulated price (see below). Gencos are therefore unwilling to offer contracts at this price, and distribution companies have to buy at the spot price and sell at the lower regulated price. The government compensated the discos by levying additional charges on users every three months to cover the losses (the so-called *z* factor). Similarly, Argentina has virtually no contracts. The reason is that distributors pay large fines for all power cuts to consumers, but the amount they are allowed to pay the generators is limited to the average of the three-month expected marginal spot prices (which is the maximum price they can charge consumers for energy). Since the distributors cannot pay for additional security, generators are not willing to sign medium-term contracts with security specifications; this implies that the distributors are just as well off by buying spot and not risking a medium term contract.

25. See and Fischer and Galetovic (2000).

Every three months Argentine consumers have to settle any differences between the regulated price paid by distributors and the spot prices, as occurs, (unintentionally), in practice in Bolivia. In contrast to Bolivia, however, this settlement can go either way. Argentine consumers thus face price risk and should respond by modifying their demand in response to expected changes in price.

In third-generation countries such as Colombia, the regulated prices are controlled via a simple scheme in which distribution companies offer tender contracts for energy. This approach is simpler than actually regulating the price, but it is more sensitive to market imperfections.[26] Apparently for this reason, Colombia explicitly restricts the size of firms in certain segments of the electricity market, and the regulator is considering the determination of a regulated reference price.

2.4. Competition in Generation

An important problem in several Latin American countries is the lack of competition in power generation. This is especially acute in Chile and Bolivia. In Chile's main interconnected system, the Herfindahl index reaches 5800, with only three major participants. The largest genco and its affiliates own about 60 percent of installed capacity; its holding company owns the main transmission facility and the largest electricity distribution company, which serves more than 50 percent of the demand of regulated consumers (these computations include Rio Maipo, an affiliate). The same company owns more than 70 percent of the remaining water rights that could potentially be used to generate electricity. This market dominance, coupled with the complexity of the electric utility legislation, has effectively eliminated entry into the market since privatization. Potential entrants are afraid of confronting this behemoth, given the possibility of discrimination within the pool, the lobbying power of the dominant firm, the problems in legislation, the possibility of discretion by the regulator, and the inefficiency of the judicial system for companies seeking redress. The formation of this dominant company was a major mistake in Chile's privatization process as well as in the period that followed, when it was allowed to buy an additional plant that was being privatized.

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26. Stacchetti (1999).

In Bolivia, the rules at privatization guaranteed no competition to the three participants for the first five years, in exchange for which the companies made investment commitments. This was a big mistake, however. Using real data, it can be shown that it was in no company's individual interest to add capacity, that is, not adding new capacity was a Nash equilibrium.[27] The fact that each firm individually would lose profits by investing, coupled to the restrictions on entry, resulted in very little capacity becoming operational during this period. Demand expansion caused the spot price to climb quite rapidly, and reserve capacity dwindled. The investment commitments made during privatization required the firms to build the new plants, but they kept them out of operation while announcing that they would be operating in the short term.[28] These announcements were incorporated into the computation of the regulated price, which explains why the regulated price was usually below the spot price. If free entry into the power generation market had been allowed, the threat of newcomers would have led the firms to start operating the new plants. In fact, when the entry restriction was close to being lifted, the plants were finally brought into service.

Argentina's market features intense competition, and energy prices are very low. This is caused in part by the distortion introduced by the capacity reward, which depends on the energy supplied by the power plant. Because many firms compete strongly in the market, it appears feasible to introduce a bidding system in the near future.[29] Colombia also features many competitors, but there is always the nagging worry that firms will integrate horizontally, thereby reducing competition and affecting the working of the spot market.

3. Transmission

In the previous section we assumed that power plants and large users (including discos) were all located in the same place. This section analyzes the more realistic case in which plants and users are spatially distributed**.** To allow the possibility of competition, the market requires a network through

27. See Rios-Cueto (1999).
28. In one case, it was necessary for the regulator to physically take over the plant to start generation.
29. As an intermediate stage, the marginal cost bids will probably last a week rather than the present six months.

which electricity can be sent from producers to consumers, with no discrimination among the various participants in the market with regard to network access. The transport system can be divided into transmission and distribution, though the precise legal division varies from country to country. For our purposes, transmission refers to high voltage lines carrying energy over long distances, whereas distribution refers to the network of low voltage lines within a city and its environs. We assume that all participants in the wholesale market are connected to the transmission grid.

The regulatory frameworks of all Latin American countries consider transmission to be a natural monopoly that requires regulation. Hence countries that have privatized or are privatizing their electricity sectors have implemented nondiscriminatory open access rules in transmission. Moreover, they have chosen a multilateral approach where a common grid is financed by all users.[30] This scheme is consistent with the minimum-cost dispatch rule (based on bids or marginal costs) adopted by most Latin American countries. The challenge is to develop efficient rules to allocate the cost of the grid among users. Inefficient cost allocation could hinder competition in the wholesale market and provide inappropriate economic signals for the expansion of the electric system. Latin American countries have used or proposed different criteria for allocating transmission costs among grid users. Countries have also established different rules for financing expansions of the transmission system. In some countries—mainly in Central America—the transmission company is responsible for the expansion of the system, while in other countries the users propose and finance expansions. The degree of market regulation varies from country to country, as well.

Finally, ownership of the system differs within the region, although all Latin American countries grant concessions to private investors for the construction of new lines even when the main grid is publicly owned. In most South American countries, the main transco, which handles the dispatch of energy from power plants and in some cases operates the system, is still controlled by the state. Several countries plan to privatize their transmission systems in the future, but so far only Argentina, Bolivia, and Chile have done so. In Central America, transmission companies will remain in public hands and retain exclusive rights to international interconnections. Central America needs to integrate its markets in order to reduce market power, increase security at a reasonable cost, and to take advantage of scale

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30. Rudnick and others (1999).

economies. Central American countries have therefore signed an interconnection treaty, but implementation is still at an early stage. Integration will work better if regulation in Central America converges, especially in transmission, but this may require regulatory changes. The decision to maintain state ownership is a means of retaining flexibility, since it is more difficult to change the laws after privatization as companies complain that it represents regulatory takings.

3.1. Cost Allocation

Allocating transmission payments among the different users requires identifying the system that must be paid and the costs that must be covered.[31] In general, Latin American countries provide for payments to economically adapted systems (that is, systems that are not overbuilt). The owner of the transmission system receives a predefined payment that covers operation and maintenance costs plus the long run annualized replacement value of lines and other equipment required by the grid. The exception being Argentina where the investment cost is not remunerated. Most countries apply some form of incentive regulation, that is, the costs that are compensated are only those of an efficient firm. The allocation of these costs among users is a complex issue, and schemes that appear similar can lead to widely divergent results.

Large economies of scale in transmission systems complicate the allocation of transmission costs among users. One obvious source of revenues is the marginal cost corresponding to the differences in energy and capacity prices at different locations, since it represents the marginal value added by the grid. However, the existence of scale economies in transmission imply that these payments generally are not sufficient to amortize the grid. Countries in the region have adopted two-part tariff systems, in which a fixed payment is added to the marginal income to finance the system. For instance, in Bolivia the fixed payment represents more than 90% of the total payments (Tardío, 2000).

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31. Rudnick and others (1999).

In theory, the fixed cost should be apportioned to users according to the benefit each of them derives from the transmission system.[32] Now, the difficulty in identifying the beneficiaries and the extent of the benefits increases exponentially with the complexity of the grid. The same transmission line might benefit consumers or generators depending on time of day, season, hydrology, or other conditions. The problem is that the allocation of payments affects the localization of power plants and consumers and hence the cost of the transmission system. By making users and consumers pay for the benefits they derive from the transmission network, they internalize the impact of their localization decisions on the cost of the network.

Argentina and Chile, the first countries to deregulate their electricity sectors, chose to allocate transmission payments solely to gencos. According to Rudnick and others,[33] this was justified by the belief that gencos required the transmission services to reach consumers. Furthermore, at the time, a large fraction of the demand in both countries was concentrated in a single city, where the marginal gencos were located, and the systems were simple lineal or radial transmission grids. Systems have become more complex, however, and this approximation may no longer be appropriate. Countries that underwent deregulation later used a different approach. In Peru, although only gencos pay transmission costs, they are allowed to pass them on to their regulated customers, which means there are few incentives to localize close to users. Other countries, such as Colombia and Bolivia, divide transmission costs between gencos and consumers. Moreover, Colombia's regulation explicitly imposes the condition that costs should be split equally between consumers and gencos.

Measuring users' benefits in order to allocate the fixed cost of the transmission system is not an easy task. It requires detailed studies that must incorporate many assumptions to arrive at a result. Consequently, Latin American countries have resorted to gross simplifications. The fixed cost of transmission is usually allocated on the basis of some *ex ante* measure of network use, except in Peru where gencos pay connection tolls as a proportion of their firm energy. Most countries define a two-step process. First, regulators determine each user's *area of impact (area de influencia)*. This usually consists of those components of the transmission system—lines, transformation stations, and other

32. Using the Shapley value imputation to cover fixed costs would be better, but determining the imputations is not an easy task.

33. Rudnick and others (1999).

installations—that are affected by a marginal increase in the power injections of a generator or by the withdrawals of a consumer.[34] Most Latin American countries measure the impact during peak conditions, but it could also be computed using other operating conditions, as is done in Bolivia.

The second step in the process is to allocate among users the cost of the facilities included in the area of impact. These *distribution factors* are usually based on the maximum power to be transmitted, either during peaking conditions or at other times[35]**.** Rudnick and others show that the choice of rules for measuring usage has an important effect on the outcome. In simulations performed for Chile, the results differ widely, with allocations of the fixed cost to generators ranging from 17.6 percent to 87.0 percent, and with the share of an individual plant fluctuating from 0.7 percent to 13.0 percent.[36]

Usage of the transmission network is measured either by simulating the expected operation of the system under optimal economic dispatch rules over a finite horizon or by using historical data as in Argentina. No country uses *ex post* reconciliation of predicted and realized flows. The operational decisions by the network user are therefore not affected by the choice of method for allocating payments. Nevertheless, the choice might have a serious impact on investment decisions, as discussed below. In addition to marginal rates and tolls, some countries levy wheeling charges for contracts between generators and consumers located outside their area of impact. Spiller argues that these wheeling charges create inefficiencies by reducing consumption below the optimal level and creating market power in isolated zones.[37] Finally, the locational premium may be insufficient to promote investment in far-away generation, reducing the use of the transmission link.

Some countries exclude congestion rents, which arise from constraints on the transmission grid, from the marginal charges paid to the grid owner. This exclusion distorts the operation of the system, as marginal costs are not properly measured. Excluding congestion rents from the variable income also increases the size of the fixed cost, which is undesirable given the difficulty of allocating the fixed cost among users. On the other hand, if the owner of the grid keeps the congestion rents (as occurs in some

34. An alternative would be to define the area of impact as those components of the system that are affected by the maximum injections of a plant or by the maximum demand of a user.
35. In Bolivia, once the area of influence is assigned to consumers, the toll depends solely on the amount of energy and not on the location (also called stamp rule). In the case of generating plants within an area of influence, payments are assigned according to the firm power of the plant.
36. Rudnick and others (1999).
37. Spiller (1995).

countries), this creates perverse incentives for the grid owner to manipulate dispatch and prevent grid expansion in order to increase congestion rents. Hogan proposes assigning the congestion rents to users according to ownership rights.[38] The income from the initial auction of capacity rights should be used to reduce the fixed cost, and the pool operator would simply act as a conduit for the distribution of congestion rentals. Argentina uses a related approach, in which users pay congestion rents into a fund that is used to finance grid expansions.

3.2. Expansion of the Transmission System

Most Latin American countries, except some Central American countries, do not require the owners to expand the transmission grid. This implies that the open access obligation to third parties is limited to installed capacity. The expansion of the system is usually proposed and financed by users, but it requires the approval of the regulatory agency, the pool operator or both. The expansions have to be consistent with the economically adapted system designed by the regulator. Chile is an exception, since the decision to expand transmission is left solely to interested investors.

Spiller discusses two ways of financing new investments in transmission: *ex post* cost recovery and *ex ante* subscription of investment costs.[39] Both methods are used by Latin American countries. If investment is recovered through *ex post* lump-sum payments, it does not distort the system's operation. Spiller emphasizes, however, that if the lump-sum payments are based on use measures, this method might lead to an inefficient pattern of investment in generation. For instance, payments could discourage gencos from investing in distant locations even when there is excess transmission capacity.[40] Also, gencos that are considering investing in a new plant will not take into account the possibility that their choice of location may force an investment in transmission, while locating at other other potential sites might have no effect on investment.[41] Even when the supplementary fixed-cost charges are independent of use, they could discourage efficient generation investment if the charge is excessive. In Peru the *ex*

38. Hogan (1993).
39. Spiller (1995).
40. Excess transmission may appear when transmission expansion takes place in discrete jumps due to economies of scale.
41. This last possibility seems unlikely, however, when transmission companies have no obligation to serve and when the system expansion is regulated and requires the agreement of other users, as in some Latin American countries.

post payments depend solely on firm capacity, so they provide inadequate economic signals for location.

Under the subscription method, users who benefit from the investment agree in advance to pay the fixed charge required to finance the investment, usually under a long-term contract. The grid will be expanded when the benefits accruing to a coalition of users exceed the expansion costs. Because of scale economies in transmission development, the efficient expansion path exceeds the amounts required by present users. Once the investment is made, the open access requirement enables some users to benefit from an investment towards which they did not contribute. This free rider problem can be reduced if a third party, such as the pool operator, allocates the fixed cost among users. This approach does not completely solve the problem, however. Since future users will free ride on the investments paid for by current users, gencos may decide to postpone their own capacity investments until the conclusion of the expansion, thus avoiding payment. This situation leads to underinvestment in both transmission and generation, which increases generation and transmission congestion costs. This problem is somewhat mitigated if subscribers are awarded the rights to eventual future congestion rents.[42]

Most Latin American countries employ the subscription method. Users request and, after approval from the regulator, pay for new transmission capacity undertaken on their behalf. Argentina uses two different schemes for financing transmission expansions. The first scheme consists of an agreement between the transmission firm and the users who finance the expansion, in which the users have the rights to congestion rents during the fifteen-year amortization period of the investment. In the second method, the process is when a percentage of the eventual beneficiaries request an expansion. The pool operator then estimates the allocation of the fixed cost of the expansion to eventual beneficiaries. The project is rejected if more than 30 percent of eventual beneficiaries oppose it. If the project is approved in a public hearing, the regulator calls for a public auction of the construction, maintenance and operation contract. Bidders compete on the basis of the annual levy to be paid by beneficiaries. This second scheme should facilitate agreements by reducing free riders However, since there is no consensus on the cost attribution procedures, those that feel harmed by the allocation are

42. Hogan (1993).

likely to reject it. In fact, the incentive process to promote new investment in transmission is being revised, as investors have become reluctant to invest in new lines.[43]

Financing new lines has become a major problem, since the fact there is no payment for the capital cost of existing lines encourages overuse up to the saturation point of the lines. After a long process, only one new line (500 Kv and 1300 Km) has been built. Experts believe, however, that the system requires at least three major new lines. A new, untested rule will allow new lines to be built at the investor´s risk, in exchange for a regulated toll which covers investment costs.

3.3. Regulating Transmission

Latin American countries display large differences in their approach to regulating transmission. Chile has, by far, the least-regulated transmission in the region. Although the legislation and the regulating agency set some guidelines, transmission fees are directly negotiated between the transmission company and each genco; lack of agreement leads to a compulsory arbitration process. Transmission franchises are subject to free access rules, but they are not required to build new lines, and new franchised lines are not evaluated by the regulator. All users share the cost of lines, so they could be required to pay for undesired investments that provide benefits for other users. Moreover, since it is difficult for parties to agree on the efficient transmission system required, there is an incentive to overinvest. In partial mitigation, the regulator does provide a ten-year investment plan for generation and transmission that minimizes the present-value costs of investing in, operating and rationing the system. This plan is only indicative, but it can be used in legal arbitration.

Negotiations between the Chilean gencos and transmission companies have never been successful, leading to arbitration. The outcome of arbitration is not predictable, because the rulings do not create jurisprudence. The problem is further complicated by the fact that the largest genco owns the grid company. Since the grid owner has no service obligation, the grid company has been accused of

43. El Salvador has a similar system: those that require expansion pay for it. However, the pool operator may ask the regulator to approve so-called common benefit expansions and then request that the beneficiaries finance them.

favoring its parent company. Colbun, an independent genco, eventually built a line that runs parallel to the main transmission line after being unable to reach an agreement with the transmission company, but scale economies in transmission give a competitive edge to the genco that owns the trunk lines. Building a new line was an inefficient option, but the genco preferred the independence gained through owning its line to negotiating with an unregulated monopoly owned by a rival.

These difficulties have created uncertainty in the development of the generating sector, which appears to have foreclosed new entry into the sector. In June 1997, the Chilean Antitrust Commission ruled that within a "prudent" period, the main genco's transmission subsidiary should become an independent joint-stock company operating exclusively in the transmission segment, thereby opening up the company for other parties to participate in ownership. In 1998, the Chilean regulation was modified to correct some of the problems that had been observed. According to the new rules, the regulator is responsible for determining each generator's area of impact, whereas before it was negotiated. There is some scope for regulatory discretion, but this seems to be a minor problem in comparison to the previous situation.

Most other countries regulate the transmission sector better. In particular, no other country allows a genco to control a transmission company. In these countries, the regulator or pool operator determines the cost to be recovered by the transmission company and its allocation among users. In Argentina, Bolivia and Brazil, the pool operator pays the transmission company a fixed annual fee, which is then divided among users. In Guatemala, if the parties cannot negotiate a mutually satisfactory agreement on fixed payments, they are regulated. Expansion of the system requires the agreement of a set fraction of participants, the approval of regulators, or both conditions. Regulations restrict cross-ownership between generators or distributors and the transmission system. Furthermore, transmission companies are not allowed to trade in the electricity markets.

It is probable that the Chilean experience with transmission, together with the belief that generation and commercialization would be more competitive if transmission was adequately regulated, influenced the design of the closely regulated transmission systems used in the countries that reformed their electricity sector later. However, the gains from better regulation of transmission are offset somewhat by the lack of consensus on the allocation of transmission costs among users. Methods for allocating the fixed cost vary from country to country. Since none of the methods have analytical

support, users tend to contest the allocation scheme if they feel they are being treated unfairly. This has led to conflicts both between interested parties and with the regulators. The volatility of transmission charges has slowed the expansion of the grid, as it does not provide a stable signal for operation and expansion. Moreover, inefficient pricing systems can impair competition and provide inappropriate economic signals for system expansion.

What is perhaps most surprising is that transmission systems are relatively inexpensive, amounting to only a small fraction of investment in power generation. Nevertheless, the disputes over the allocation of these costs can have important effects on the system's efficiency. In some cases, simple yet theoretically imperfect rules might be more efficient than cumbersome rules that are supposedly efficient. The absence of new investment in transmission observed in several countries might reduce competition in the sector, as appears to be thecase in Bolivia (Tardío, 2000).

4. Distribution and Commercialization

Distribution companies deliver electricity from the transmission network to small users. (Large users often connect directly to the transmission line.) They receive the electricity at substations where the voltage is lowered from the high voltage used in transmission to the low voltage used by the distribution network. Most Latin American countries award distribution franchises (sometimes nonexclusive) that obligate the disco to provide service throughout the franchised area. Early Latin American reformers established a system in which distribution companies buy electricity for their clients and pass on the purchase price. The regulated price for a small consumer thus has two distinct components: the price at which discos buy electricity and the value added of distribution (VAD). Later reformers, following the example of the United Kingdom, explicitly separated local transportation from commercialization services, allowing for retail competition. Small consumers contract directly with any of various competing energy brokers. The brokers, in turn, buy electricity in the wholesale market and pay regulated fees to transmission and distribution companies.

Since distribution is a natural monopoly, it is subject to price regulation in all Latin American countries. Although the VAD may or may not include commercialization services (mainly measuring,

invoicing, and commercial branches), regulation in Latin American countries shares some common principles. The main objectives are the self-financing of companies, the pursuit of efficiency, and the transfer of efficiency gains to consumers. The VAD is usually set so that a hypothetical efficient distribution company would achieve a predetermined rate of return. The region's regulatory systems show important differences, however. With respect to service quality regulations, some countries have concentrated on establishing technical standards, whereas other countries have chosen to measure service standards. Countries also differ in the types of subsidies they use: while some use cross-subsidies among classes of users, others use direct subsidies to special groups that are financed from the public budget.

4.1. The Theory behind Incentive Regulation

The two distinct options for price regulation are the traditional cost-of-service approach, which sets rates to reflect the costs of the firm, and the incentive price-setting approach, which stresses the pursuit of efficiency within the firm. In its standard form, the traditional approach was based on rate-of-return targets, but it faced at least two problems: the lack of incentives to reduce costs (since inefficiencies would be passed on to consumers) and the overexpansion of investment through the Averch-Johnson effect (1962).

Incentive regulation attempts to correct the main problems of the rate-of-return approach by separating a firm's realized costs from the tariff-setting process. The two most common versions are the price cap model and the efficient firm model. In the latter, prices are set at a level at which an efficient firm would attain an established rate of return. Prices are reviewed every few years; between review schedules, prices are adjusted according to a relevant inflation index, but firms keep any profits from cost reductions. The problem with this approach is that it requires knowing the costs of an efficient firm. If only one firm provides the service, it will have a strong influence on what the regulator considers efficient. When the same service is supplied by different local monopolies facing similar conditions, however, the information monopoly is weakened. For example, the most efficient firm in the group could be used as the model for the other firms, setting up a case of yardstick competition. If there is no

collusion, firms have incentives to lower their costs because this does not affect their own tariffs. Countries with few firms could resort to international benchmarks.

The price cap model, also known as RPI-X, consists of limiting tariff increases via a cap that moves according to price inflation minus an X factor representing an *ex ante* estimation of future efficiency increases. Every few years, X is adjusted. Any increase in efficiency beyond X is appropriated by the firm. If X is an unbiased estimator of future productivity gains, this scheme provides the correct incentives to the firm. An advantage of this approach over the efficient firm model is that it only changes the rate at which prices move over time and not the price itself, which reduces the level of conflict in the regulatory process. Although there is no explicit mechanism for determining the X factor, price caps have another advantage over efficient-firm pricing: it is easier for the regulator to identify potential efficiency gains in an existing firm than to build a credible model of an efficient firm from scratch.

An alternative to price setting is temporary franchising, as pioneered by Demsetz.[44] The franchise is periodically auctioned, and it is awarded to the bidder offering to charge the lowest price for the service. The incentives for raising productivity are similar to those of incentive price regulation. The main advantage of this scheme over price regulation is that the tariff arises from a competitive process. The main difficulty arises when substantial sunk costs are required.[45] Here, two possibilities arise. First, the fixed capital may be owned by the government, in which case the problem is to ensure that the franchisee will provide adequate maintenance. Second, all or a substantial part of the investment may be financed by the franchisee. Here, the challenge is to provide appropriate incentives for the operator to make the required investments, especially close to the end of the franchise period. Dnes proposes that when the franchise is rebid, the new operator should compensate the old one for investments made.[46] Investments should be valuated through a technical process, which clearly outlines arbitration clauses in case of disagreements. The valuation process once again leaves room for disagreement, however.

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44. Demsetz (1968).
45. Williamson (1985) has noted that the type of long-term contract usually found in the Demsetz scheme is subject to renegotiation, in which case many of the attractive properties of the approach are lost.
46. Dnes (1991).

4.2. Implementation

Chile was the first country to explicitly introduce incentive regulation. The 1982 legislation defines rate-setting schemes based on marginal cost pricing in simulated efficient enterprises. The VAD is recalculated every four years by determining an efficient firm's operating and maintenance costs (including energy losses) and setting rates to provide a 10 percent real return on the replacement value of assets. These rates are then applied to existing companies. If the actual average industry return on the replacement value of assets exceeds 14 percent or falls below 6 percent, rates are adjusted to the nearest bound. The hypothetical efficient firm is built on the basis of the real firm that the regulators believe to be the most efficient among existing firms, introducing an elementary type of yardstick competition.

Most Latin American countries have followed Chile's lead in implementing efficient-firm pricing. Brazil, Colombia, El Salvador, Nicaragua, Panama, and Peru, among others, use benchmarking in defining efficient standards, although they differ in their actual implementation. In Brazil, large discos companies were split and sold to distinct investors, such that the largest cities now have two or three discos, which are allowed to compete. In addition to yardstick competition, therefore, some direct competition among discos is expected, at least along their common boundaries. Smaller countries, such as Panama, are more likely to rely on international benchmarking when defining the efficient firm. However, even in El Salvador, existing distribution companies were split to allow for direct competition along their boundaries: two different companies service the capital city. Bolivia has opted for price caps, as have most countries in the rest of the world. In the Bolivian system, five cost elements have specific gain factors.

Argentina chose a different approach. Distribution companies operate under a 95-year concession contract, which is broken into nine 10-year management periods (except the first period, which lasts 15 years). Before the start of each management period, the regulator sets the tariffs to be applied during that period, and then calls for a competitive auction for control of the disco. If the current owner submits the highest bid, it retains ownership. Otherwise, the investor offering the highest bid obtains the concession and pays the bid price to the incumbent holder. During a management period, tariffs are adjusted according to an index formula contained in the concession contract. Tariffs may be reviewed after five years, if the disco files a petition with reasonable arguments. The regulator can grant

the desired tariff increase after conducting a public hearing and contracting an independent cost study. Distribution costs are computed as the average incremental cost of the network, adjusted for a least-cost expansion investment plan for an efficient firm and based on demand growth assumptions. Buenos Aires is divided into two distribution areas assigned to different companies, but these are not allowed to compete.

4.3. Results among the Earlier Reformers

Only in Chile and Argentina has enough time passed to make it possible to draw conclusions. The privatization of distribution companies led to substantial new investments and efficiency improvements in both countries. The largest Chilean distribution company more than doubled its sales from 1987 to 1997. It also managed to cut energy losses from 19.8 percent to 8.3 percent and to raise the number of clients per worker from 376 to 703 in the same period. The service expansion is explained by the relaxation of financial constraints faced by public enterprises, combined with a comparatively stable, impartial regime of contract law for privatized utilities.[47] Private-sector managerial capacity explains the gains in labor productivity. The isolation of public services from political pressures has also helped to improve performance indicators: before privatization, political meddling made it almost impossible for state-owned companies to dismiss low performance workers, especially if they had political backing. Finally, the new regulatory system encourages efficiency.[48]

Despite these gains, however, after two rate reviews, the prices of regulated services have not fallen to reflect the huge productivity gains that have been achieved since privatization. Between April 1987 and April 1997 the all-inclusive tariff paid by consumers in the central (and most densely populated) zone in Chile fell by 11.4 percent in constant dollars, although the generation price fell by 37.4 percent, energy losses were reduced substantially, and labor productivity increased significantly in the same period. It also become easier to stop service to customers who did not pay their bills and to penalize those who pilfer services. Consequently, the rate of return of distribution companies rose significantly. For instance, the largest distribution company (serving almost 40 percent of the population)

47. Levy and Spiller (1996).
48. Levy and Spiller (1996).

saw its rate of return increase from 10.4 percent in 1988 to 35 percent in 1997. The profitability of other discos followed a similar trend. Such rates are way above those being earned by gencos, even though gencos are subject to far greater uncertainty since they do not have a captive market and they face hydrological variations.

It seems that problems inherent to incentive regulation have prevented efficiency gains from being fully passed on to consumers. Rate setting based on simulated efficient enterprises requires considerable judgement, and the regulatory process is increasingly becoming a bargaining process. The Chilean regulatory agencies do not seem to be well prepared to deal with this type of process: they are at a technical disadvantage with respect to the regulated firms. Moreover, privatized utilities have political and social leverage, and they exert enormous influence in defining the efficient firm. Recent rate-setting episodes have also exposed the problem of information asymmetry: regulators have had serious difficulties in gathering ~~precise~~ cost data from utilities. Efficient-firm regulation requires actual data from firms, as costs depend on customer density, topography, and demand per customer, among other factors. It is therefore difficult for regulators to build a credible efficient firm when they do not have full access to companies' data.

Specific aspects of the Chilean legislation also contribute to these results. Regulators are not allowed to make public the information used to compute rates except to the regulated firms, which blocks consumer protection agencies from counterbalancing the pressure that firms place on the regulator. In Argentina, in contrast, tariff reviews require a public hearing. Moreover, the existing regulation in Chile does not promote truthful data revelation. The procedure operating costs of an efficient firm are established using the weighted average of estimates made by the National Energy Commission (NEC) and by consultants hired by the industry. This procedure provides obvious incentives for each party to bias its estimates, and discrepancies in the estimates have exceeded 50 percent. A better solution would be for an arbitrator to have to choose between the two estimates.

Argentina similarly experienced significant improvements in coverage and efficiency after privatization. Annual investment rose five times, labor productivity more than doubled, and distribution losses fell from 28 percent to 10 percent in five years. It is still to early to tell whether the periodic rebidding process will work. The risk is that the information advantage of the incumbent franchisee might inhibit potential bidders, reducing the scope for competition. The main advantage of Argentina's bidding

mechanism is that it reduces the risk of conflicts during price setting. However, tariffs still correspond to the rates set by the regulator at privatization, as firms chose not to ask for a tariff review after the first five years.

4.4. Retail Competition

Some Latin American countries, such as Brazil and El Salvador have opted for retail competition. Colombia is planning to reduce the free-client threshold to zero, thus permitting retail competition. To ensure fair competition, regulations must establish nondiscriminatory open access to distribution networks. Enforcement of nondiscrimination rules is facilitated when distribution companies are excluded from the commercialization business. Some countries allow distribution and commercialization companies to compete in supplying service to end users, imposing restrictions on the participating discos. Brazilian discos need to keep separate accounts for their commercialization activities, and cross subsidies are forbidden.[49] In El Salvador, when a disco supplies service to the end user, the terms and conditions of supply require annual approval from the regulator, while other suppliers are free to set their own tariffs.

Other countries, like Chile, do not allow competition in retail markets, and only generators are supposed to compete for servicing large customers. Nondiscriminatory access to the distribution network is a requisite for sustainable competition, but under the present legislation in countries such as Chile and Argentina, distributors have priority in using the network. Introducing independent power brokers would therefore require significant changes in the legislation.

An important advantage of separating energy sales from distribution services is that it reduces the number of activities that need to be regulated. In Chile, for example, discos have increased their profits by raising the prices of related, nonregulated services. Some discos have profit rates of 50 percent in meter rentals, and they exhibit huge differences (as high as fourteen times) in their rental rates, with no economic justification. Consequently, the regulator is considering the regulation of related services. Some of these services could be provided by third parties, but the close relation between the disco and the customer acts as an entry barrier. If energy sales were separated from distribution,

49. It is needless to mention that lack of compliance with this clause is unlikely to be verified.

however, most related activities would be priced in a competitive market, thereby eliminating the need to determine the charges for commercialization services. Moreover, traders would be interested in seeing that distribution companies are properly regulated, which would provide a counterweight to the disco lobby. Separation would also make it possible to supply residential consumers with energy plans that are adapted to their circumstances (namely, different combinations of price, quality of service, and volume), without imposing too heavy a burden on the regulator.

4.5. Large Customers and Distribution

In most countries of the region, only large consumers, whose maximum power demand exceeds a certain threshold, are free to buy energy from sources other than the disco. If generators or electricity traders choose to sell energy to large customers located inside the area serviced by a distributor, they may require use of the disco's network, unless they want to duplicate lines. In Chile, use of the distribution grid must be negotiated with the disco, and it is not regulated. Consequently, there is very little competition for large clients within distribution franchises, since a genco must negotiate with a competitor to establish a toll for the use of the grid. If the parties cannot reach an agreement, they enter a mandatory arbitration process which is lengthy and onerous and has uncertain results. This procedure is sufficiently uncertain for independent generating firms to have desisted in their attempt to supply such clients directly. In addition, the distributors are the generating firms main customers, so taking clients from them is bound to be costly. Lack of competition for supplying service to large customers has important ramifications for regulated customers, because the regulated node price cannot deviate too much from average contract prices**.** Argentina has followed a different approach: distribution companies are required to provide transport services at a regulated rate to all consumers with a maximum demand greater than 30 kilowatts.

5. Regulation Compliance and Governance

Regulatory compliance and governance has long been a weakness in Latin America. The region's regulatory agencies face three main problems, none of which is specific to developing countries but which are exacerbated in that environment.

- Regulators are often subject to pressures from populist politicians and industry lobbies.
- Regulators receive low salaries and can be captured, either in revolving-door schemes or through outright corruption.
- Badly designed regulation systems operate within the context of an inefficient, often corrupt judicial system.

Given the large sunk costs and the lengthy periods required to recoup investments, Levy and Spiller emphasize the importance of regulatory institutions as a means of ensuring investment in an area in which it is easy to expropriate firms.[50] Specifically, the lack of independent institutions in the region creates an expropriation danger. This form of governmental opportunism can lead to inefficient levels of sectoral investment. Hence, Spiller and Viana-Martorell claim that in Latin America, the advantages of flexible regulation have to be measured against the possibility of regulatory opportunism.[51] They praise the extreme rigidity of the Chilean system and the fact that regulatory measures can be appealed in the courts as factors which attract investment to the sector.

5.1. Populism and Regulatory Rigidity

Before the reforms, the region's politicians often pressured regulators into setting tariffs below economically sustainable levels.[52] The quality of service was correspondingly low, as the state-owned electric companies were often starved for funds for investment or even maintenance of equipment. In several countries, state-owned companies appeared after the tariff-setting process of originally private firms surrendered to populism and rates were set too low for private investment, which paved the way for the takeover or replacement of private utilities by the state.[53]

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50. Levy and Spiller (1996).
51. Spiller and Viana-Martorell (1996).
52. See Spiller and Viana-Martorell, (1996).
53. See Harberger (2000 [1956]) for the point of view at the time; see Rudnick (1998) for a retrospective of the development of the electricity sector in South America.

When the new electric utility law was introduced in Chile in 1981–82, the legislature was interested in assuring potential investors that they would not be expropriated by the regulator. Decision power was therefore taken away from regulators and embedded into the law. This led to an extremely comprehensive and complex electric utility law, which incorporated details normally left to regulatory determination. At the time, this revolutionary approach seemed a good bargain: in the early 1980s, Chile needed to convince investors that the rules of the game would not change according to regulatory whim.[54] This mechanism was effective in attracting investment when the sectors were eventually privatized, but it had the undesired effect of making the regulatory framework rigid and unadaptable.

The system's inflexibility became quite costly as the environment changed, as shown by the 1998–99 drought. During the crisis, the whole governance system collapsed, and the country was subject to avoidable and prolonged black outs, without any compensation to users to date. This caused an estimated $300 million in damages to the economy. The failures of regulatory governance during the crisis derived in part from the lack of flexibility embedded in the law, which reduced the powers of the regulator to respond quickly to the drought, coupled with pressures on the regulator from producer lobbies.[55]

The rigidities in the Chilean legislation became entrenched because none of the existing players wanted to change the rules for fear of arousing populist instincts in the legislature. For instance, Chilean law does not provide for special payments to plants that provide modulation services (that is, plants that react to small short-term changes in demand or supply to maintain equilibrium), and there is no easy way of supplying differentiated service to residential consumers without legislative intervention. Moreover, from the point of view of established generating companies, one of the "benefits" of the complex regulatory environment is that it deters entry, since inside knowledge of the system is necessary to operate efficiently. Only when a major crisis strikes the system (as with the 1998–99 drought and blackouts) are legislators able to push for changes. Even then, reforming the system is not guaranteed, since the various players will lobby against changes that affect their interests.

Privatization of public utilities became more fashionable in the 1990s, and the risk of expropriation became correspondingly smaller. Because the danger of populist measures was perceived

54. See Spiller and Viana-Martorell, (1996).
55. Fischer and Galetovic (2000).

to be lower, countries undertaking reform during this period were able to design less-detailed electric utility legislation without deterring investors. In Argentina and Colombia, the law outlines major principles only, leaving the regulatory agencies to determine the details.[56] This approach has obvious advantages if the fear of regulatory takings is small. Even when the regulator is legally allowed to change regulations, however, lobbying may thwart any efforts to do so. For example, Argentina has found it difficult to change the distortionary mechanism for rewarding capacity, because some firms will inevitably be harmed by the reform proposals.

Similarly, Colombian law sets out the basic principles, and the regulator then interprets the law to determine the regulatory details. Under this approach, companies direct clarifications of the legislation to the regulator, which issues binding statements to the firms. This information is publicly available on the Internet, so any potential investor can analyze the trends and decide whether to enter the market.[57] Regulatory flexibility can also lead to problems, however. After the 1992 drought, the regulator became extremely sensitive to the possibility of power cuts during future droughts; a first draft of restrictions on the use of stored water was therefore introduced at privatization. The newly privatized company established long-term supply contracts with users based on its water reserves, but when the drought of 1997 arrived, the rulings on water use became stricter (a case of regulatory takings), and the company had to buy high-priced energy in the spot market to fulfill its contracts. The company still had substantial unused reserves after the drought. Plans are currently underway to introduce an options market for water rights, which will provide signals to the market and the regulator and make it less likely that the regulator will intervene in the market again.

5.2. The Institutions of the Electricity Sector

In Latin American countries, regulating the electric system is usually accomplished through two independent regulators, the first of which deals with planning, policy, and norms and the second with supervision of the norms themselves. This follows from the same principle that argues for separating legislative design and enforcement. This separation is not always complete, however. In Chile, for

56. Bolivia and Peru followed the route of detailed legislation.
57. In Argentina, public hearings on proposed regulatory changes are used to a similar effect.

instance, the distribution charge is calculated in part by the the National Energy Commission, which is normally in charge of policy, and in part by the Inspectorate of Electricity and Fuels, which is normally in charge of regulatory supervision and enforcement. This is inconsistent with the arguments in favor of two regulatory organizations, and it leads to problems such as regulatory inefficiency, infighting, and weakness towards organized pressures.

Another major institutional player is the pool operator. The internal organization of the pool, its members, and its governance rules play important roles in the smooth functioning of the electric system.[58] This is especially true in countries using marginal cost pricing, in which the pool operator designs optimal control models that determine the operation of reservoir-based power plants. Once the rules have been set, they become very difficult to change, because the affected firms considered such actions regulatory takings. Since regulatory changes usually affect firms differently depending on the type of plant they own, the regulator may be accused of favoring specific firms when introducing regulatory changes in the pool.

In Chile, governance and operation of the were not carefully designed.[59] Until recently, the Chilean pool operator had no infrastructure, and the dispatch was made by the transmission company, which was owned by the largest genco. Decisions must be consensual, and any divergences are settled by the regulator. The constant conflicts among the members have led to difficulties in coordinating operations. (For example, between 1994 and 1997 the regulator had to settle twenty disputes between gencos.) Moreover, net buyers in the pool during supply restrictions (usually hydroelectric gencos) have refused to pay what they considered exorbitant prices during periods of supply restrictions, that is, during droughts, appealing the issue to the inefficient and unprepared legal system. This behavior creates weak incentives for generators to invest in thermal as opposed to hydroelectric capacity.[60]

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58 During the 1998-1999 drought in Chile, hydroelectric-based gencos arbitrarily decided not to pay the (high) spot price of energy needed to fulfill their contracts, since the Chilean pool establishes a service obligation on generating plants, but not a legal obligation of payment. In another example, the firm power assigned to a plant was arbitrarily reduced to one twentieth of the value calculated by the newly independent pool operator by a majority of the members of the pool directorate.

59. The designers were influenced by their previous experience of collaboration under a state-owned system; they were unaware of the potential for disputes between members of the pool or of how a good design could minimize these disputes and the associated coordination costs.

60. It also deters new entrants which would add thermal capacity in the expectations of high prices under droughts.

The legal responsibility of the Chilean pool operator has also been weak as: until recently, it did not even have a precise legal status. Recent legal reforms have led to some improvements relating to its independence and composition. New rules introduced in December 1998 establish the legal status of the pool operator, increase its responsibilities, and make it more independent. Finally, the spot price in the pool covers a complex process of bargaining among members over issues such as modulation services, problems relating to minimal operating size and others. A new entrant with no contracts would confront these implicit rules which are not reflected in the spot price.[61] The risk of discrimination from the other producers is large unless the new entrant has long-term contracts for a large fraction of its production.

Peru and Colombia have systems that improve on the Chilean pool operator. Though the composition is similar (except that Colombia admits a representative of the discos), they have their own independent personnel. Their decisions also require unanimity, and disputes are settled by the regulator. In Argentina and Bolivia, the pool operator encompasses all the participants in the market: generators, large users, transmission companies, distributors, and the regulator (presumably to represent the interests of regulated users). Decisions in both countries require a majority rather than consensus, and in Bolivia the regulator can only cast a vote in case of a tie. In Argentina the regulator has veto power, which tends to reduce the pool operator's independence and allows political considerations to intervene in technical procedures.

5.3. Penalties and Enforcement

As mentioned above, South American regulators suffer from a credibility problem as a result of the perceived threat of regulatory takings.[62] In an effort to correct this perception, first-generation reformers overprotected companies. They ended up with a weak regulator that lacks relevant information or the means of obtaining it, is starved for funds, is subject to strong pressures from electric utility lobbies, and does not have the tools to enforce regulations. Chile is remarkable for the weakness of its regulator, which has never been able to impose the compensations to consumers envisaged for

61. See also Wilson (1999).

62. See Spiller and Viana- Martorell (1996).

energy shortages. The possibility of appealing regulatory decisions to the courts has weakened the regulator even further.[63] In Bolivia, the rules prohibiting the entry of new gencos in Bolivia for five years after privatization had the effect of delaying the start-up of new operating plants for the period of the restriction. Established gencos repeatedly announced their opening and then delayed it.[64] Once again, the regulator is too weak to act appropriately, namely, to lift the entry restriction from companies that announced projects but did not follow through.

Argentina, in contrast, has shown that a regulator can impose strong penalties: when the distribution company for Buenos Aires left a neighborhood without electricity for two weeks, the penalties exceeded $70 million. Colombia also has a strong regulator, which took control of the system during the 1997 drought to prevent hydroelectric power companies from using their water too fast. Of course, this turned out to be a costly misperception.

Finally, economies of scale in regulation and competition put small countries at a disadvantage.

5.4. Vertical Integration and the Regulation of Monopoly Power

Regulatory weakness exacerbates the problems of vertical integration. The extensive literature on the relation between vertical integration and monopoly shows that vertical integration can be beneficial or detrimental for social welfare, depending on the specifics of the case.[65] It has often been argued that the possibility of double marginalization in oligopoly markets or the existence of economies of scope imply that in general, vertical integration is beneficial and is not related to monopolization of a market.[66] Economides argues that when monopoly is held over a bottleneck, vertical integration provides incentives for the monopoly to expend resources in degrading the quality of service to competitors.[67] Using Economides as a basis, Engel, Fischer and Galetovic show that in the context of imperfect information by the monopolist (and the regulator), open access and service requirements are insufficient to promote competition, and vertical separation reduces the possibility of monopolization of

63. Recent changes to electric utility legislation have given more power to the regulator. It is not clear, however, if the changes were thought out carefully or were a hasty response to the deficiencies exposed during the drought.
64. Apparently they made these announcements in order to curb pressures against the restriction.
65. See Perry (1989).
66. See Brunekreeft (1997); Emmon (1997); Lee (1995); Kaserman (1991).

downstream shipping by a seaport, even if we admit the possibility of underhand agreements between the regulated port operator and independent shipping companies.[68] Galetovic uses these ideas to develop a model of the electricity sector in which vertical integration of a regulated transmission company leads to higher consumer prices than does the absence of vertical integration, even when any degree of scale economies is present.[69]

Chile is the only South American country with no restrictions against vertical integration of transmission and generation. Other countries in the region learned from this experience: Chile saw no new entry into the system, and competitors in the generating industry filed many complaints against the dominant company, which was also the owner of the transmission system. When these other countries reformed their regulatory frameworks, they all introduced restrictions on vertical integration.[70] It is interesting that Chile is also the country in which it is easiest to enter the markets for distribution and transmission, which are notorious natural monopolies, while the lack of restrictions did little to promote entry into generation, where the benefits of entry are larger.

6. Conclusions

Since the early days of reform of the region's electricity sector, the approach which seemed revolutionary at the time has become common sense.[71] The Chilean reform, which is only twenty years old, looks primitive from the point of view of later reforms, serving as a transition between state-owned firms such as Electricité de France, which was very influential among the main designers of the Chilean reform, and the full-fledged market-oriented reforms of the Nordic countries.

Countries that reformed their electricity sectors after Chile incorporated substantial changes, which led to freer markets and enhanced competition. Although these changes have improved the functioning of the markets, they cannot be considered best practices in regulation by international

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67. Economides (1991). See also Vickers (1995) for the case of a regulated integrated monopoly lowering quality to downstream competitors.
68. Engel, Fischer and Galetovic (2000).
69. Galetovic (2000).
70. Several countries have also limited horizontal integration.
71. See Spiller and Cardilli (1997) for another example of small Latin American countries leading the pack in telecommunications.

standards. The fear of regulatory takings is still present in Latin America and it affects the scope of reform. The following areas are key to improving the region's regulatory frameworks and smoothing the workings of the energy market.

- Countries should move toward a system in which various markets interact: long-term contracts, financial and physical derivatives, and a series of markets close to the time of dispatch. Having various markets serves two purposes: it reduces the importance of market power by reducing the amount traded in the market that is most sensitive to market power (namely, the final adjustment market), and it rewards plants of different capabilities, such as fast response but high cost, as well as low-cost baseline plants. Energy markets should be coupled with markets for ancillary services that provide quality.
- Market power has been a problem in most bidding systems, so it is essential to unbundle firms vertically and horizontally or at least to establish enforceable rules that ensure that small, nonintegrated entrants have a chance to compete in the market. The market rules should be designed to reduce market power, and they should be flexible so that they can be modified if firms learn to use the rules to the detriment of competition.
  - Distribution should be unbundled into its components: commercialization services firms and a local transport monopoly. Commercialization services are potentially competitive if entrants are not mistreated by the incumbent. This is a distinct possibility if the incumbent retailer is owned by the owner of the regulated distribution grid. If ownership separation is impossible, the regulator should carefully monitor the quality of grid service and try to prevent the grid owner from discriminating against rivals. One attractive possibility is dividing the incumbent retailer into several firms. From the users' perspective, retail competition creates plans that are tailored to their specific needs. Moreover, retail competition simplifies tariff setting, since the only regulated service is the rental price of the wires.
  - Transmission constraints should occur in efficient transmission systems, but they should provide signals for increased investment in transmission or in generating plants in importing areas. The

Nordic approach of dynamic transmission areas, in which prices are adjusted to eliminate excess flows in congested transmission lines, appears to provide the correct signals for investment (even though economies of scale imply that efficiency requires a fixed payment for investment in additional transmission capacity). On the other hand, too much stress on efficiency might lead to constraints that reduce he possibility of entry. A limited degree of overinvestment in transmission might be beneficial because it leads to more competition at relatively little cost.

- The pool operator should include the various participants in the market and not become a genco club, as it currently is in several Latin American countries, since exclusive participants will set internal rules that limit entry into the market. However, this option might lead to serious coordination problems. Alternatively, the operator could be independent of the market participants and follow rules that are designed in a public process. In this case, there is a difficulty in finding an appropriate objective function for the operator so that it has the right incentives. However, it is better than the option of having a pool operator that is associated to only one side of the market.
- As international connections become more common, thereby increasing local competition, it is important that operating rules be compatible among the various countries involved in these supranational electric systems.

The early Latin American reforms were useful both in leading the way for other countries and in raising efficiency in their own countries. Nevertheless, they are now obsolete and should be updated. There is no single, best approach at present, as countries experiment with a wide array of different institutional arrangements. Any new reforms should therefore include flexible rules that can be adapted to new advances in the regulation and design of electric systems.

Appendix: Optimality of the Marginal Cost Rule.

We consider a simple model in which there are only two types of plants, with marginal costs $c_1 < c_2$ and unit capacity costs $F_1 > F_2$. The capacities of the two types of plants are q_1 and q_2. All transactions are spot price transactions: since this is a long-run model without uncertainty, there should be no need for contracts. Plants receive a payment for energy equivalent to their sales at the spot price. They also receive a power payment that covers the unit cost of capacity in type 2 plants. We assume perfect divisibility of plants.

The power curve q(t) shown in the bottom of figure 1 describes the ordered demand, which is assumed to be fixed, for energy versus hours (or half hours, depending on the dispatch) of the year. The hour of highest demand in the year occurs at T = 0. The lowest demand occurs at $\underline{T}$. Let T_1 be defined by $q_1 = q(T_1)$. For all $T \in [\underline{T}, T_1]$, supply can be covered by the plants with low marginal costs. For all hours $T \in [0, T_1]$, demand requires that in addition, at least some of the capacity of plants with high marginal costs be used and $q(0) = q_1 + q_2$. The total cost of each type of plants can be written as:

$$C_1 = c_1 \int_{T_1}^{T} q(t)dt + c_1 \int_{0}^{T_1} \bar{q}_1 dt + F_1 \bar{q}_1$$
$$C_2 = c_2 \int_{0}^{T_0} \{q(t) - \bar{q}_1\} dt + F_2 \bar{q}_2$$

$$C_1 = c_1 \int_{T_1}^{T} q(t)dt + c_1 \int_{0}^{T_1} \bar{q}_1 dt + F_1 \bar{q}_1$$
$$C_2 = c_2 \int_{0}^{T_0} \{q(t) - \bar{q}_1\} dt + F_2 \bar{q}_2$$

(1)

and total revenues, including the capacity payment are:

$$R_1 = c_1 \int_{T_1}^{T} q(t)dt + c_1 \int_{0}^{T_1} \bar{q}_1 dt + F_2 \bar{q}_1$$
$$R_2 = c_2 \int_{0}^{T_1} \{q(t) - \bar{q}_1\} dt + F_2 \bar{q}_2$$

(2)

Obviously, the plants with high marginal costs cover their costs exactly. To find the installed capacity on plants with low marginal costs, note that $R_1 = C_1$ implies that $(c_1\text{-}c_1)T_1 = (F_1\text{-}F_2)$ or;

$$T_1 = \frac{F_2 - F_1}{c_2 - c_1}$$

To show that this assignment of capacity minimizes cost, consider the upper part of figure 1. It shows the total cost of operating the two types of plants as a function of the number of hours of operation. Clearly, it is efficient to operate the plants with low marginal costs if they are used for more hours than the intersection of the two curves, which occurs precisely at T_1.

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