Hacienda Pública Española / Revista de Economía Pública, 185-(2/2008): 115-149

Multi-Output Compensation System in Electricity Distribution: The Case of Spain*

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Recibido: Septiembre, 2007
Aceptado: Junio, 2008

Abstract

The Marco Legal Estable provides us with a rare opportunity to study a system of multi-output reimbursements applied to the distribution of electricity in Spain over an extensive period of time: 1988 – 1997. To do so, an analysis structure is proposed based on a Bennet-type indicator (1920), which allows us to identify the variations in the revenues associated with the activity of electricity distribution, for each of the companies and each one of the outputs. The Law recognized, regulated and compensated four products differently. This indicator is broken down into a quantity effect and a reimbursement effect. The quantity effect evaluates the impact on revenues of the variations in demand for each of the outputs, and the reimbursement effect the modifications in revenues due to the changes in the remuneration per product, which are based on standard costs. Modern production theory is used to explain the quantity indicator by means of a productivity and activity effect. Lastly, the productivity indicator is broken down into operating efficiency, allocative efficiency and technical change. To do so, a sequential-type technology is defined whose information begins in 1952. Mathematical programming techniques are used to resolve the proposed economic decomposition.

Keywords: electricity distribution regulation, Marco Legal Estable, electricity distribution revenues, Bennet indicator.

JEL classification: L51, L54

* We would like to thank Inés Macho and Francesc Trillas of the Universitat Autònoma de Barcelona and Luis Maqueda, Milagros Abedillo and Antonio Candela of the "Comisión Nacional de la Energía" for the comments on the previous versions of this study. We would also like to thank the tremendous work done by the two anonymous evaluators. Naturally, this does not free us from the responsibility with regard to any possible errors that the study may contain. This study has been possible thanks to the financing provided by the Ministry of Science and Technology SEJ2007-67737-C03-01/ECON and the Catalan Autonomous Government - la Generalitat de Catalunya 2005SGR 00813.

1. Introduction

Since the early nineteen eighties, there has been a major wave of reforms that have affected many traditionally regulated sectors all over the world. The electricity industry has been no exception. In Spain, in a simultaneous way to the more closely studied case of Great Britain, a period of major transformation in the electricity sector was initiated, one that was embarked upon as a consequence of the severe financial difficulties that the industry was experiencing. This process of change culminated in 1987 with the approval of the system of regulation known as the Marco Legal Estable (henceforth MLE), which remained in force until 1997, and was a fundamental change of approach compared to previous regulating frameworks[1].

At present, the sector is fully involved in implementing the Electricity Sector Law (ESL), in force since 1998, and which has meant the liberalization of the sector. This implementation is being accompanied by an intense debate regarding the functioning of the model being established and the achievement of the goals set out in the Law. Numerous studies have been carried out in this respect since the law came into force; for example Arozena, Kühn, and Regibeau (1999), Fabra (2006), Fabra and Toro (2005), Vives (2006), and of special relevance, Pérez Arriaga (2005).

The activity of distribution, together with transportation, continues to be considered by the current legal framework to be regulated. Some innovative aspects introduced by the new regulation of distribution activity have been studied by Grifell Tatjé and Lovell (2003). However, the legal application of their regulations did not come into force until 2000, with the reform of the rules regarding their reimbursement still pending[2]. We can therefore consider this activity to still be in a confusing transitional stage, with many aspects of the MLE remaining in force[3]. Only more recently seems to have been a clear desire to provide a solution to the economic aspects of this activity in the framework of the New Electricity Sector Law[4]. In this context, it seems relevant to study the only clearly defined system of regulation that distribution in Spain has had up until now, i.e. the MLE system. This should be done by analyzing the consequences of its application, with an eye to the possible reproduction of its virtues in a new regulatory framework and with the aim of overcoming the defects or difficulties associated with it.

The MLE regulated all electricity activities, with one of its fundamental elements being the concept of *standard cost*, i.e. the setting by the Administration of objective costs for the system that would eliminate surplus expenses, and on which the companies' reimbursement would be based. Authors such as Laffont and Tirole (1993: 86) have regarded it as a rare example of a "yardstick competition" system. Others, such as Rodríguez and Castro (1994), maintain that it is more a case of a system of regulation based on maximum prices. As we shall see, the regulation of electricity distribution was based on a complex multi-output system open to a number of different interpretations.

The MLE has been the object of attention in literature, although most studies have dealt with issues related to adverse selection. For example they attempt to decide whether the way in which the law was designed, and especially the way that certain costs were set, was adequate or not. In this sense, most authors sustain that in setting these costs there was a lack of objectivity and thoroughness. The studies by Fernández (1994), Martínez (1991), Rojas (1995), Ariño and López de Castro (1998), among others, are along these lines. In contrast, this study will focus on aspects related to the moral hazard. Specifically, it will analyze how the parties involved behaved once the MLE was in force, and will attempt to provide empirical evidence of how the system has worked. From this standpoint and for the period that the MLE has been in force, Arozena and Waddams-Price (2002) have studied the efficiency and productivity of a set of coal-fired electricity generating plants in a theoretical context defined by the Malmquist indexes (1953) [Färe *et al.* (1994)]. For the same time period, Ramos and Martínez (2004) have studied technical change by applying a methodology based on costs, but defining the vertically integrated electricity company as a unit of analysis, and considering both the generation and distribution of electricity. This article complements those that have preceded it, since for the first time it studies the activity of electricity distribution for this period in isolation, as this is the only activity, together with transmission, that is still currently considered as being an object of regulation.

In the literature dealing with the MLE, there is consensus in considering that the function of a distributing company's profits is defined by the difference between the standard costs recognized and the costs incurred by the company. This being the case, the MLE left open certain regulatory aspects that were the object of continual renegotiation and various revisions throughout the period in which it was in force. In this sense, it is worth stressing that in Spain the activity's regulator is the government itself, and that there is a tradition in the sector that the latter should reach a consensus with the companies regarding regulation. With regard to this state of affairs, Rodríguez and Castro (1994: 181) pointed out that the companies' behavior might be directed, not towards decreasing their total incurred costs, which would be socially desirable, but to increasing their revenues. In other words, their interest lies in increasing the recognized standard costs. This possible behavior was also highlighted by Laffont and Crampes (1995: 140). In addition, we should bear in mind that the majority of an electricity distribution company's inputs are quasi-fixed. Thus, any strategic behavior by the company aimed at obtaining greater profits should mainly take the form of a search for greater revenues.

The main aim of this study is to examine the companies' behavior by analyzing how the revenues obtained from the regulator for the distribution activity have evolved[5]. In this sense, it should be pointed out that the information that can be obtained from a focus based on revenues is similar to the one for costs. However, in the former instance, the assessment is made by means of the incentive system provided by the regulator, while in the latter the prices of the inputs are used. This study based on the revenue side has been possible due to the researcher's access to the MLE reimbursement system, which details every aspect of the activity for each distribution company and for the whole period that the MLE was in force. Information is available for each of the products, understood as the energy delivered at the different voltage levels as well as all retailing activity. These products were regulated in a differentiated way by the MLE.

The existence of a differentiated regulation for each of the products encouraged a “partial” strategic behavior by the company. That is it could exploit the weaknesses of the system, identifying and applying pressure to its weaker points, which could only affect aspects related to one or several products. Everything seems to indicate that this strategic behavior, aimed at obtaining higher revenues, took place in the Spanish power distribution companies, leading to a significant increase in the quality of the service. This was especially the case over the period from 1988 to 1993. There was no economic incentive for the improvement of this concept during this period, thus constituting a rare case of positive externality.

In order to perform this analysis, we propose the use of a new methodology based on a Bennet-type revenue indicator (1920) [Diewert (2005)], which allows the required information to be differentiated according to product. In addition, our aim is to decompose this indicator in accordance with the economic theory of production, allowing us to quantify the variations of productivity in terms of revenues. We will also examine a series of issues that are central from the regulatory point of view. This decomposition was carried out using mathematical programming techniques based on ‘Data Envelopment Analysis’ (DEA) models (Charnes *et al*, 1978). The use of DEA in the analysis of electricity distribution regulation is very common in the literature. For example, Bogetoft (1997), Kurhonen and Syrjänen (2003) Agrell *et al,* (2005) have applied it to the analysis of this activity[6].

It should also be noted that, in analyzing how company revenues evolve we are opening up a new field of study, since studies existing up until now of electricity distribution have focused mainly on three areas: i) Analysis of scale economies and the efficiency of distribution companies. Studies in this line of research include those by Giles and Wyatt (1993), Salvanes and Tjotta (1994), Burns and Weyman Jones (1996) and Yatchew (2000); ii) The differences between the public and private electricity distribution companies (Hjalmarsson and Veiderpass (1992a,b), Pollit (1995), Kumbhakar and Hjalmarsson (1998); and iii) The analysis of proposals for regulating the activity (Weyman Jones (1992), Norwegian Water Resources and Energy (1997), OFGEM (2000)).

The article is structured in the following way: Section 2 provides a description of the most significant aspects of the reward system set out in the MLE; Section 3 presents the theoretical model; Section 4 explains the key aspects of its implementation; Section 5 is a discussion of the data employed and the definition of the variables; Section 6 sets out the main results obtained; and lastly, the section containing the conclusions closes the article.

2. The Marco Legal Estable

The enactment of Royal Decree 1538/1987 of December 11th would define a new regulatory framework for the electricity sector in Spain known as the Marco Legal Estable, and this was to remain in force formally until 1997[7]. The MLE is, without a doubt, a complex regulating system developed in several phases, by means of various Royal Decrees and Ministerial Orders. This legislative complexity is more marked in the case of electricity distribution since, unlike generation, it defines and regulates four products differently. In theory, the legislative changes introduced to the MLE over time should be understood as an attempt to remedy the defects detected in the regulation system. As can be seen in Table 1, which provides a summary of these legislative changes for the case of electricity distribution in which we are interested, it was from 1993 onwards that important changes were introduced. By this time enough empirical evidence of its functioning had been accumulated.

Table 1
SUMMARY OF THE MLE FOR THE ACTIVITY OF ELECTRICITY DISSTRIBUTION

Legal Framework	Product affected	Regulation introduced
Royal Decree of December 11th 1987	All	Setting of the terms according to which the electricity distribution costs are to be standardized
Order of February 19th 1988	All	Establishing the compensation costs between systems and designing the inter-companies compensations system.
Order of December 19th 1988	High voltage	Expanding the factors on which the rate of return on high voltage investments depends.
Order of December 22nd 1988	All	Establishing the parameters for correcting the deviations in determining the tariff.
Order of December 22nd 1988	High voltage	Setting the standard distribution costs for high voltage, and the procedure for updating them.
Orders of December 3rd and 17th 1993	High voltage, medium voltage, low voltage, retailing, structural costs.	• Change in the index for updating the standard values in high voltage. • Change in the criteria applied to the rate of return on high voltage investments. • Considered as standard structural costs differentiated for the activities of distribution and generation. • Replacing the coefficient for correcting the fixed standard costs for facilities <36kv by a supplement to investments. • Setting new commercial unit costs and the adjustment index at 0.75. • Introduction of a timid economic incentive for quality of service.
Resolution of January 20th 1994	High voltage	Change in the criteria applied to the rate of return on high voltage investments.
Order of December 15th 1995	High voltage, medium voltage, low voltage, commercial management	• Changes in the criteria applied to the rate of return on high voltage investments. • Review of commercial costs. • Review of structural costs. • Change in the updating rate of operating costs for all voltages.
Order of May 29th 1997	Retailing	• Establishing programs to encourage demand that will be added to the commercial costs.

The MLE had two fundamental goals: To create a system that allows the economic and financial balance of the Spanish electricity sector to be re-established, and to ensure that this system is compatible with the introduction of efficiency incentives. To attain these goals, the MLE's regulation system was structured into two levels: i) the determination of the electricity tariff according to the standard costs per product; and ii) a distribution mechanism of the tariff funds among companies based on the average revenues and the average standard costs of the sector. We shall describe this regulation in detail below.

2.1. Standard Costs in Electricity Distribution

According to the MLE, the fundamental premise for calculating the tariff is that it covers the exact cost of the service. In this way, the tariff embodies the total cost of the system, obtained by adding together all the costs established for all the elements and all the companies of which it is comprised. These costs are calculated in a standard way, i.e. in a way that is common for all the companies. In addition, it is governed by the principle of a uniform tariff throughout the national territory, without price differences resulting from the companies' different cost structure. This calculation is made in average terms by taking the simple quotient between the standard costs of the system –plus surcharges and external costs– and the estimated kw/h demanded every year[8].

In this way an incentive regulation system is introduced: it establishes that companies are not to be compensated for the costs that they really incur, but for costs evaluated according to a standard that objectifies the necessary expenses and avoids the reimbursement of superfluous costs. These standard quantities will be the revenues received by the companies in the sector, regardless of their real costs.

To compensate the activity of electricity distribution, the MLE establishes a differentiated regulation for each of the products supplied: i) electricity supplied at high voltage; ii) electricity supplied at medium voltage; iii) electricity supplied at low voltage; and iv) commercial retailing. To these costs are added what are referred to as *structural* costs. As to the actual supply of electricity a threshold is established which is relative to the voltage level, applying different criteria for those costs incurred in voltages higher than 36 kV to those of the costs incurred in lower voltages. In addition, a differentiated regulation is applied for fixed costs and operating costs in each of the voltages considered.

High Voltage Regulation

The standard costs of high voltage distribution facilities (between 36 kV and 132 kV) are compensated in accordance with physical units (kilometers of power line, number of cells, transformation power), regardless of the effective use of these. In this way, standard costs are recognized according to the type of facility. The recognition of these costs should allow, on the one hand, the recuperation of the gross value of investment via amortization, and on the other, the correct remuneration of the capital. The financial cost is determined by applying a rate of return on the standard net value of the facilities[9]. It is important to stress that the guidelines to be followed to calculate this rate of return were constantly being changed throughout the time the MLE was in force, being revised in 1993, 1994 and 1995.

In order to recognize new high voltage investments (and exceptionally medium and low voltage), the MLE required an investment plan to be presented to and approved by the Regional Government[10]. It should be stressed in this sense that, although the mandate for the approval of facilities had been transferred to the regional governments, it was not these organisms but rather the Ministry of Industry and Energy that was charged with paying the companies. In this way a disfunctionality was introduced to the state's decentralization process. This was because the organism approving the new investments, and as a consequence recognizing the new costs, was not the one that subsequently paid for them.

For their part, the high voltage *operating costs* embraced the set of costs deriving from operating and maintaining the facilities. These costs were also standardized based on unit costs per physical units: circuit length per lines, and number of connections per substations[11]. Up until 1995, the updating of these costs was performed by applying the RPI, and from 1995 onwards, by applying an updating rate of RPI minus two points.

Regulating Medium and Low Voltage

In terms of the costs corresponding to medium and low voltage facilities (less than 36kv), these are remunerated basically according to the energy circulated by these facilities and not based on physical units as in the case of high voltage[12]. Two types of standard costs are recognized: fixed costs and operating costs.

In order to establish the fixed annual standard cost, a number of standard unit values per kW/h circulated are determined, differentiating between medium and low voltage[13]. These values are updated on a yearly basis. This is done though a price index calculated by considering, in equal proportion, the retail price index and the industrial product price index[14]. It is curious to note that the way in which the MLE regulates the *fixed costs* of medium and low voltage has been completely overlooked in the literature. The standard unit values are adjusted by an important discounting factor (X) of 25% of the aforementioned price index[15]. In consequence, we can see how the 1987 legislation already introduced (although only partially, since it did not affect operating costs nor all the products) the Littlechild recommendations (1983) to adjust unit prices by a discount rate. Notice that this discount rate of 25% is fixed and independent of the efficiency levels in electricity distribution. This aspect contradicts the widespread belief that the costs in the MLE were only adjusted upwards, as inflation levels alone were considered.

In addition, the adjusted fixed costs could be affected by a correcting coefficient derived from: the geographical dispersion of the market, whether the power line network was underground and other special characteristics of the areas supplied. This correction coefficient could not be higher than 10% of the fixed costs. In 1993, the coefficient was replaced by a supplement aimed at encouraging investment in distribution lower than 36kv. In this case the supplement could not be higher than 14% of the fixed costs. Its calculation would take into account not only the aforementioned special characteristics of the market, but also investments aimed at improving the quality of the service. For the first time, and having been in force for six years, the MLE referred specifically to quality and introduced a slight incentive aimed at its improvement. This incentive would remain in force until 1997, only to be later abolished by the current Electricity Sector Law in 1999. This gives us an idea of the little importance that the regulator gave to quality in designing the reimbursement system for the sector.

In the case of the *operating costs* of voltages below 36kv, standard costs were also established according to the energy circulated. This was done with the difference between low and medium voltage facilities being made according to the same criteria as for fixed costs. These unit costs were updated annually in line with the RPI until 1995, without applying any kind of discount. From this year on, the RPI minus three percentage points was applied to them.

Regulation of Commercial Management and Structure Costs

Another concept to be taken into account are the retailing commercial costs, which include activities related to managing and developing the customer market. In doing so a differentiated regulation is also being applied to these costs. The standardization of these costs is performed according to the number of contract policies and the power subscribed in voltages greater than 1kv[16]. The adjustment coefficients between both elements are established every year by an Energy Department Resolution. In the same way, the costs are updated annually according to the corresponding RPI. In 1993, the unit costs for commercial management were modified, and the only discretionary remuneration element was eliminated when the adjustment index was set at 0.75. These costs were revised once again in 1995, and in 1997 an incentive for demand management was added to commercial costs.

Lastly, structure costs have to be considered. Up until 1993 these costs were considered to be one more concept of the costs included in the tariff, without distinguishing which part corresponded to generation and which to distribution. From this year on, these costs were differentiated according to how they corresponded to each of these activities, with their parameters, method of calculation, and updating being defined in a differentiated manner. In this way, for distribution a standard unit cost per kw/h supplied to the end user was established, to be updated annually in line with the corresponding RPI. In 1995, a mere two years after being set, the structure unit costs were modified.

2.2. The Inter-Companies Compensation System

The final stage of the MLE corresponds to that known as the inter-companies compensation system[17]. As we have seen, each electricity company was recognized as having standard costs in accordance with the activity of distribution arising from the sum of the standard costs associated with each of the products discussed in the previous sub-section. To these costs were added those corresponding to generation, which is not an object of study in this paper. In order for the aforementioned regulation system to work, the standard costs that the company were recognized as having had to constitute their only revenues. Nonetheless, the company supplied the electricity to the end consumer and obtained payment by means of the rate charged for this service. The aim of the compensation system was to ensure that the final payment received by the company, essentially its revenues, would be exactly equal to the amount of the standard costs recognized by the regulator. To do so, each company's tariff receipts were adjusted, with this adjustment being defined as the compensation system.

With CS_h being the standard costs recognized for company *h* by applying the reimbursement system described in the previous sub-section, where $CS_h = \Sigma_{m=1}^{4} CS_{mh}$, with m = 1,…,4 expressing the number of outputs. If we assume that there are *n* distributors, the total standard costs recognized in the system would be defined by: $\Sigma_{i=1}^{n} CS_i$. In addition, if R_h expresses the amount charged by *h* to its customers, we see that $\Sigma_{i=1}^{n} R_i$ expresses the total receipts associated with the distribution activity. One of the conditions that needs to be met is that the total receipts for the system (R) are the same as the total standard costs recognized (CS), i.e.: R = CS. In other words, $\Sigma_{i=1}^{n} R_i = \Sigma_{i=1}^{n} CS_i$. The compensation associated with company *h*, which we express as z_h, is simply equal to:

$$z_h = CS_h - R_h \tag{1}$$

When $z < 0$, the company will pass on the previous quantity, received from its takings, to the remaining companies. When $z > 0$, the company will receive this quantity from the other companies. Naturally, when $z = 0$ the amount received is exactly the same as the standard costs recognized, and it will neither return nor receive any funds. Notice that: $\Sigma_{i=1}^{n} z_i = 0$. In this way, the profits of a company *h* are defined by:

$$\pi_h = CS_h - \Sigma_{j=1}^{N} \omega_{jh} x_{jh}, \tag{2}$$

where $(x_1,...,x_N)$ expresses the vector of the inputs used in distribution, and $(\omega_1,..., \omega_N)$ the vector of their respective prices. Thus, the sum of the previous expression represents the company's total operating costs. Expression (2) tells us that the profits come from the difference between the standard costs and the total operating costs incurred in providing the service.

The equality R = CS enables us to rewrite expression (1) as:

$$CS_h - R_h = \left[CS_h - \bar{p} y_h\right] + \left[\bar{r} y_h - R_h\right] = z_h^1 + z_h^2, \tag{3}$$

where y_h defines the quantity of energy delivered by the company *h* to the consumer and $\Sigma_{i=1}^{n} y_i = y$ the total quantity of energy supplied by the system, i.e. by all the companies taken as a whole. Expression (3) explains the difference between the standard costs and company *h*'s receipts. The first addend, z_h^1, shows that the standard costs recognized are different from those coming from the product between the sector's average standard costs (average reimbursement) ($\bar{p}$ = CS/y) and the energy supplied by *h*. The second, reveals that the receipts obtained do not coincide with that which would be obtained by applying the average tariff for the sector ($\bar{r}$ = R/y). This is a common situation, since the company takings depend on its demand structure, which may easily fail to coincide with the sector's average structure. Lastly, we would like to draw attention to the fact that the MLE introduced a correction to this last expression. The company would only give or receive *half* of z_h^2, i.e.: ½(z_h^2). This means that distributor *h*'s revenue function would be rewritten as:

$$\text{Income}_h = CS_h + \frac{1}{2}\left[R_h - \bar{r}y_h\right],$$

and, in consequence, the function of profits (2) as:

$$\pi_h = \left[CS_h + \frac{1}{2}\left(R_h - \bar{r}y_h\right)\right] - \sum_{j=1}^{n}\omega_{jh}x_{jh}, \tag{4}$$

where the total revenue for *h* is provided by the standard costs, to which additional revenues are added that are equal to half of the difference between the amount received and that calculated using the average tariff for the sector. The profits are equal to the difference between these revenues and the total costs incurred.

2.3. How can we classify the MLE?

It could be deduced from the aforementioned description of the MLE that it obeys the philosophy of price cap regulation, since the standard costs are the prices that the companies will initially charge for each of their outputs. In addition, as we have demonstrated, in the case of medium and low voltage, a part of the remuneration was adjusted by an annual discount factor of 25% of the average RPI and the industrial product price index. However, Crampes and Laffont (1995) and Laffont and Tirole (1993) consider the MLE to be a yardstick competition model (Shleifer, 1985). In a yardstick competition system the company's reimbursement, or its recognized costs, are calculated using the average costs of the sector. In this context the *compensation* associated with a company *h* is defined by:

$$z'_h = \left[\frac{\sum_{i=1}^{n}\sum_{j=1}^{N}\omega_{i,j}x_{i,j}}{y}\right]y_h - R_h, \tag{5}$$

where the first term on the right-hand side of the equation defines the costs that the regulator recognizes for the company. In a simplified way, this can be expressed by CR_h. The interpretation of expression (5) is exactly the same as that already mentioned in the case of expression (1). The profits for company *h* are now given by:

$$\pi_h = CR_h - \sum_{j=1}^{N}\omega_{jh}x_{jh}, \tag{6}$$

where we can see the similarity with expression (2). In certain contexts, the yardstick system also regulates the company takings, in such a way that this is calculated using the information regarding the average revenues for the sector, in an analogous way to that already described for the costs. In (5), these estimated revenues replace those really obtained by the company (R_h). By introducing this modification, the profit function that Crampes and Laffont obtain (1995: 130) is equal to (4), but replacing CS_h by CR_h, and without the 1/2 value. Here we see a repetition of the similarity already observed between expressions (2) and (6). These similarities are what prompted previous authors to classify the MLE as a yardstick regulation system. However, Crampes and Laffont (1995: 130), point out that: "*although CR_h is non manipulable by h (at least if there are a considerable number of firms in the sector), such is not the case for CS_h. The system should therefore have an extremely strict government managerial staff who avoid letting standard costs drift to a firm's advantage…, In essence, [while]Yardstick Competition is anonymous, this is no longer the case for its Spanish adaptation, which brings up the question of standard cost review and new investment evaluation*" (our notation).

On this point, we should remember that distribution companies could increase their recognized standard costs by investing and putting new high-voltage facilities into service, regardless of their use. It would be difficult to refuse requests for new facilities since, as we have already commented, it was the regional government that approved facilities whereas it was the Ministry of Industry and Energy who were charged with reimbursing them. In consequence, we see how one of the fears voiced by Crampes and Laffont materializes, although only "partially", since it only affects one of the products regulated. Additionally, it should be said that the literature has been especially critical of the process employed in determining the standard costs. For example, Ariño and López de Castro (1998) point out that these were set using the criterion of real historical costs, whose basic element of information are the ledger values of assets. Hence, the standard basic value simply reflected the average of the historically incurred costs, a value that could hardly be seen as coinciding with the ideal, objective, inefficiency-free value that the standard aimed to constitute[18]. The hypothesis that the standard costs associated with high-voltage facilities were overvalued is quite plausible, which would provide an additional incentive for putting new facilities into service.

Lastly, it should be pointed out that the function of revenues defined in (4) has earned little attention in the literature. This tells us that the company will receive half of the difference between its receipts and that calculated for the average receipts for the sector. The introduction of this modification might encourage a behavior of adverse company selection in relation to the customer, since the distributor will seek to contract high voltage connections, with a higher tariff, even though the customer might not need it, in order to make the difference greater. In an internal report in 1996, FECSA company supported these arguments.

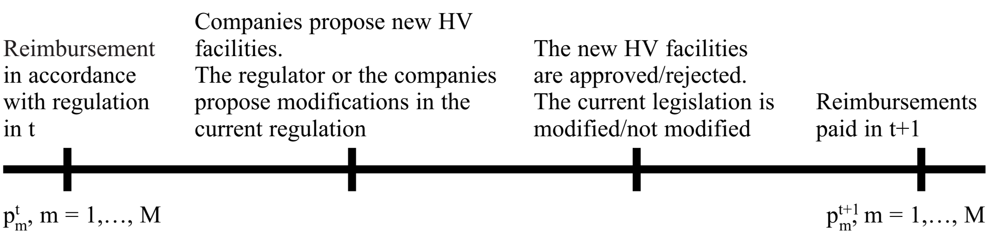
3. The Theory Model

3.1. The Bennet Indicator

Expression (2) reveals that the company can increase its profits by obtaining higher standard costs or by reducing operating costs[19]. The literature has paid special attention to the impact that regulation has had on total company costs. But as far as we know, no articles that have turned their attention to how the company manages to generate its revenues. This lack of attention may be due to the fact that most of the studies assume, either implicitly or explicitly, that the process of regulation is closed, correctly designed, and that the company does not have the capacity of influencing it. Nonetheless, we have already seen that many aspects of the MLE have been the object of rectification over time. This fact, in itself, is indicative that the previous initial hypotheses might not be true. In addition, it should be noted that any error in the regulatory design or any influence applied by the companies should be reflected in the way that these generate their revenues. These revenues are also influenced by variables that are exogenous to the company, such as the demand they are obliged to meet. Throughout this section we will present an economic model that will allow us to study the revenues obtained by the companies, i.e. their standard costs, in a multi-output situation. To do so we will combine two economic disciplines: index number theory and the modern neoclassical theory of production, in the methodological context initially proposed by Grifell Tatjé and Lovell (1999).

Let us consider an electricity distributor *h* that produces M outputs represented by the quantity vector $y_h = (y_{1h},\ldots,y_{Mh}) \geq 0$. This company receives a reimbursement from the regulator for its outputs expressed by the vector $p_h = (p_{1h},\ldots,p_{Mh}) > 0$. As we have seen in Section 2, the regulator paid for each of the outputs in a differentiated way. For reasons of simplicity we shall use the term "reimbursement" throughout the paper to refer to the unit monetary sums that are based on standard costs, in accordance with that set out in the previous section. We shall also abandon the '*h*' notation, since all the methodology that follows is applied at company level. The revenues, i.e., the standard costs obtained by the company for the period *t* is given by the following expression: $CS^t = p^{tT}.y^t = \Sigma_{m=1}^{M} p_m^t.y_m^t$, where the superscript "^{T}" expresses the transposition of a vector.

Our aim is to identify the factors determining the changes in revenues between two consecutive periods of time: *t* y *t+1*. To do so, we began by breaking down the change in the revenues resulting from the movement from (y^t, p^t) to (y^{t+1}, p^{t+1}) into two basic components. The first of these, which we have called the *reimbursement effect*, reflects the impact on revenues of the changes in the reimbursement for the electricity distribution activity. The following general diagram summarizes how the standard recognized costs and their unit reimbursement will be affected by the recognition of new facilities and the legislation revision processes set out in Table 1.



By quantifying the modifications in unit payments (result from the changes in the reward system being applied), the reimbursement effect reveals the tensions arising between the regulator and the companies between one period and another. In addition, it will reflect the influence of the latter exercised on the regulator, as well as the approval of new facilities. The second effect, which we have called the *quantity effect*, shows the impact on revenues of the changes in energy demand, with reimbursements being kept constant.

A possible decomposition of the changes in revenues between a *price effect* and a *quantity effect* is:

$$CS^{t+1} - CS^{t} = y^{t+1T} (p^{t+1} - p^{t}) + p^{tT} (y^{t+1} - y^{t}) \quad (7)$$

and another possible decomposition is:

$$CS^{t+1} - CS^{t} = y^{tT} (p^{t+1} - p^{t}) + p^{t+1T} (y^{t+1} - y^{t}) \quad (8)$$

In (7), the *reimbursement effect* appears similar in construction to a Paasche-type price index (setting the quantity at y^{t+1}), and the *quantity effect* to a Laspeyres-type quantity index (setting the price of the outputs at p^{t}), although expressed as differences rather than ratios. The opposite occurs in (8), where the *reimbursement effect* is similar to a Laspeyres index (setting the quantity of output at y^{t}), and the *quantity effect* is similar to a Paasche index (setting the prices of the outputs at p^{t+1}). Expressions (7) and (8) can be used to construct a Bennet price indicator and Bennet quantity indicator that will be defined by the arithmetical mean of the two previous expressions. Hence:

$$\begin{aligned} CS^{t+1} - CS^{t} &= 1/2\,(y^{t+1} + y^{t})^{T} (p^{t+1} - p^{t}) \quad \textit{Reimbursement Bennet} \\ &+ 1/2\,(p^{t} + p^{t+1})^{T} (y^{t+1} - y^{t}). \quad \textit{Quantity Bennet} \end{aligned} \quad (9)$$

We can see how the *reimbursement effect* reflects the modification in the payment system adjusted by arithmetic mean quantity weights, whereas the *quantity effect* measures the changes in the quantities, adjusted by arithmetic mean reimbursement weights. Both the *reimbursement effect* and the *quantity effect* can be calculated directly from the observed data. It is interesting to observe that the structure of a Bennet indicator allows it to quantify the impact of the variations in prices and quantities on the changes in the standard costs paid to the companies, for each of the outputs. This characteristic will be especially useful in this study, since, as we have seen, products have been regulated in a differentiated way by the MLE. By using this indicator, we will then be able to evaluate the adjustments and modifications in the reimbursement mechanism in terms of revenues, over time, and for each of the electricity companies, as well as the variations in the quantities of electricity demanded.

Bennet's decomposition proposal, performed on profits, was rediscovered and studied by Diewert (2005), who has shown that it satisfies a set of desirable axioms of similar characteristics to the case of the Fisher index number. We can see that a Bennet indicator has a very similar structure to a Fisher number, although expressed in differences rather than ratios. Diewert proposed using the term "indicator" for the expression in the form of differences, and "index" in the case of ratios. We have adhered to this terminology in this article.

Grifell Tatjé and Lovell (2000) have shown how a Bennet quantity indicator of costs can be decomposed, and these same authors, in a previous article in 1999, demonstrated how a Laspeyres-type quantity indicator of profits could be decomposed (Expression 7). Grifell Tatjé and Lovell (2008) have recently applied a new methodology based on a Bennet profit indicator. In the following section we shall extend these studies by proposing a new economic decomposition of the Bennet quantity indicator of revenues (9) adjusted to the requirements of this study. Lastly, it should be stressed that expression (9) is not based on the assumption of any restrictive behavior by the evaluated company, such as the maximization of revenues.

3.2. Decomposition of the Bennet Quality Indicator of Revenues

S^t y S^{t+1}, in Figure 1, defines sets of feasible production activities in the time periods *t* and *t+1*. $P^t(x^t)$ and $P^{t+1}(x^{t+1})$ in Figure 2 defines output sets corresponding to S^t and S^{t+1}. Figure 1 expresses a general situation characterized by variable returns to scale. Hence we have $S^t \subset S^{t+1}$, since we assume that there has been technical progress. This hypothesis means that $P^t(x^t) \subset P^{t+1}(x^t)$, in Figure 2, which considers non-neutral technical change. In addition, we have $P^{t+1}(x^t) \subset P^{t+1}(x^{t+1})$, since we consider that $x^t < x^{t+1}$. In both Figure 1 and 2, in the period *t*, a company uses the input vector x^t to distribute y^t, and in the period *t +1* a company uses the input vector x^{t+1} to distribute y^{t+1}. In both figures, y^t_{RE} and y^{t+1}_{RE} express vectors of outputs that generate maximum revenues for (x^t,p^t,S^t) and $(x^{t+1},p^{t+1},S^{t+1})$ respectively, which are free of operating and allocative inefficiency. In addition, technical progress enables a greater distribution of electricity. This is defined by y^E, an output vector that generates optimum revenues for (x^t,p^t,S^{t+1}). Moreover, in Figure 2, y^C and y^D define two Debreu (1951) – Farell (1957) technically efficient output vectors for $P^t(x^t)$ and $P^{t+1}(x^{t+1})$ respectively. The aim is to explain the Bennet quantity indicator, and to do so we propose the following decomposition:

$$\begin{aligned} &1/2\ (p^t + p^{t+1})^T\ (y^{t+1} - y^t) = \\ &\qquad 1/2\ (p^t + p^{t+1})^T\ (y^{t+1}_{RE} - y^E) \quad \textit{Activity effect} \\ &+ 1/2\ (p^t + p^{t+1})^T\ [(y^{t+1} - y^{t+1}_{RE}) - (y^t - y^E)]. \quad \textit{Productivity effect} \end{aligned} \tag{10}$$

The output vectors y^{t+1}_{RE} and y^E are the main components of the *activity effect*.[20] Both vectors are defined with the technology of the period *t+1*, as shown in Figure 1. We observed that the changes in the production as a whole can only be explained by the variations in input quantities. In consequence, we can say that the activity effect measures the expansion (contraction) of the electricity distributed –free of inefficiencies– resulting from a higher (lower) availability of inputs. In the context of this study, these changes can mainly be associated with the entrance in operation of new electricity facilities. The difference between y^{t+1}_{RE} and y^E is assessed by the arithmetical mean of the output prices. The *activity effect* will contribute to an increase (decrease) in revenues for the period *t* to *t+1* when $1/2(p^t + p^{t+1})(y^{t+1}_{RE} - y^E) > (<) 0$.

Figure 1. Descomposition of the Bennet Quantity Indicator (I)

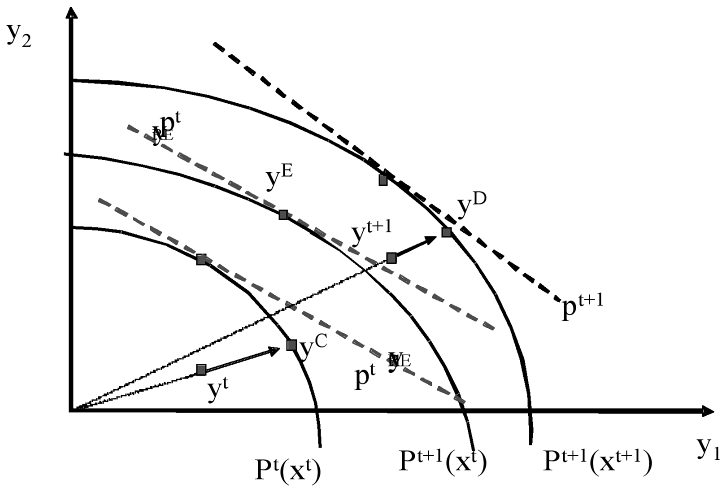


Figure 2. Descomposition of the Bennet Quantity Indicator (II)

For its part, the *productivity effect* compares the productions observed in each of the periods with their respective optimum quantities calculated with the technology of the period *t + 1*. The *productivity effect* will have a positive (negative) value when the loss of revenues obtained by operating in a non-optimum way in the period *t+1*, is less (more) than the loss of revenues resulting from the difference between the outputs observed for period t and the optimum outputs associated with (x^t,p^t,S^{t+1}). The differences in outputs are aggregated using arithmetic mean output price weights. The *productivity effect* will contribute to an increase in revenues (or to a decrease) between period *t* and *t+1* providing that $[1/2(p^t + p^{t+1})^T(y^{t+1} - y^{t+1}_{RE})] > (<) [1/2(p^t + p^{t+1})^T[(y^t - y^E)]$. In turn, the *productivity effect* can be decomposed into three more explanatory elements: an effect produced by the *operating efficiency*, a component that measures the *allocative efficiency* and the contribution of *technical change*. Hence we have:

$$
\begin{aligned}
&1/2\,(p^t + p^{t+1})^T\,[(y^{t+1} - y^{t+1}_{RE}) - (y^t - y^E)] = \\
&\quad + 1/2\,(p^t + p^{t+1})^T\,[(y^{t+1} - y^D) - (y^t - y^C)] \quad \textit{Operating efficiency effect} \\
&\quad + 1/2\,(p^t + p^{t+1})^T\,[(y^D - y^{t+1}_{RE}) - (y^C - y^t_{RE})] \quad \textit{Allocative efficiency effect} \\
&\quad + 1/2\,(p^t + p^{t+1})^T\,(y^E - y^t_{RE}). \quad \textit{Effect of technical change}
\end{aligned}
\tag{11}
$$

We should remember that y^C and y^D are Debreu-Farrel technically efficient vectors. As Figure 2 shows, the *operating efficiency effect* measures the impact on revenues of any distancing from or approach to the production frontier that is produced in the period *t+1* with regard to *t*. *Allocative efficiency* on the other hand measures the effect of the changes produced between the period *t* and *t+1* in the distance between the technically efficient radial projection into the frontier and that which corresponds to the maximum revenues given the prices for each period[21]. As the distribution companies have to supply the energy demanded, and unit reimbursements associated with the different outputs are ultimately decided by the regulator (see Section 3.1), we can consider that a correct regulating mechanism should be able to apply a system of relative compensations close to the situation of operating efficiency. In fact, it might seem that the greater the discrepancy between operating efficiency and allocative efficiency, the worse the regulating mechanism. The sum of the two effects: operating efficiency and allocative efficiency are represented in Figures 1 and 2 by $[(y^{t+1} - y^{t+1}_{RE}) - (y^t - y^t_{RE})]$, using in both cases arithmetic mean output price weights.

With regard to how *technical change* affects revenues, we should remember that y^t_{RE} and y^E are operating and allocative efficient vectors (see Figure 2). Note that in both definitions the price vector used is the same. Therefore the movement from y^t_{RE} to y^E expresses the movement of the production frontier, as for example the technical change that may be non-neutral, as in the case of Figure 2. The difference between the two vectors is again evaluated using arithmetic mean output price weights, and measures the contribution of technological progress in terms of revenues.

4. Implementing the Decomposition of the Bennet Revenue Indicator

The calculation of the Bennet indicators proposed in (9) requires information about (y^t, x^t, p^t) and $(y^{t+1}, x^{t+1}, p^{t+1})$, and this data are potentially observable. However, the decomposition of the Bennet quantity indicator presented in expressions (10) and (11) require the additional use of vectors $(y^t_{RE}, y^{t+1}_{RE}, y^C, y^D, y^E)$, which are not observable and have to be calculated. To do so we will use linear programming techniques know as Data Envelopment Analysis (DEA), initially proposed by Charnes, Cooper and Rhodes (1978). What this technique does is to compare each of the distribution companies with the best practice observed in the sample.

Normally, in DEA analysis, the technology of period *t* is constructed from the data on input and output quantities for all the producers in that period *t*. From this point of view, the information existing in periods prior to *t* is not used. In this study our aim is to follow a different approach, which Tulkens and Vanden Eeckaut (1995) have dubbed *sequential*. Sequential frontiers enable the technology of period *t* to be constructed from the data on input and output quantities of all the companies in all the previous periods, including period *t* itself. This type of analysis rules out technical regress, such as total or partial lowering of the production frontier, a situation that adapts fully to electricity distribution. With this approach we can define the set of production possibilities as:

$$T^t = \{(y, x): y \leqq \Sigma_i \lambda_i y_i^s,\ x \geqq \Sigma_i \lambda_i x_i^s,\ \lambda_i \geqq 0,\ s = 1,\ldots,t\}. \qquad (12)$$

where (y,x) is an upper-bounded piece-wise-linear surface (frontier) constructed by the union of the observations that define the best practice observed for all the years from 1 to *t* inclusively. Expression (12) defines a technology with constant returns to scale, since the sum of the λs can take any value. We should not consider this hypothesis as being restrictive, since the literature indicates that economies of scale are rapidly exhausted in the distribution activity (see for example, Salvanes and Tjotta, 1994).

The calculation of the effect of *operating efficiency* on (11) involves identifying the vectors of quantity y^C and y^D that are technical efficient in the Debreu-Farrel sense. To calculate y^C we solve the following linear programming problem for each electricity distributor $i = 1,\ldots,^o,\ldots, I_t$, in each year, $t = 1,\ldots,T$.

$$y^{oCt}/\, y^{ot} = \max_\theta \theta$$
$$\text{s.a. } \theta y^{ot} \leqq \Sigma_i \lambda_i y_i^s,\ x^{ot} \geqq \Sigma_i \lambda_i x_i^s,\ \lambda_i \geqq 0. \qquad (13)$$

Similarly, as y^D is a radial expansion of y^{t+1}, $y^D = \theta y^{t+1}$ with $\theta \geq 1$. The scalar θ is determined as a solution to a linear programming problem identical to (13), replacing the data (y^s, x^s, y^{ot}, x^{ot}), with the data, (y^{s+1}, x^{s+1}, y^{ot+1}, x^{ot+1}).

Calculating the *allocative efficiency* effect of expression (12) involves identifying the quantity vector y^t_{RE} and y^{t+1}_{RE}, where y^t_{RE} maximizes the revenues obtained with the inputs x^t, when the reimbursements given by the regulator are p^t, and with the technology sequential until period *t*. To calculate y^t_{RE} we solve the following linear mathematical program for each electricity distributor $i = 1,\ldots,^o,\ldots, I_t$, in each year, $t = 1,\ldots,T$.[22]

$$\max_y p^{ot} y$$
$$\text{s.a. } y \leqq \Sigma_i \lambda_i y_i^s,\ x^{ot} \geqq \Sigma_i \lambda_i x_i^s,\ \lambda_i \geqq 0, \qquad (14)$$

In the case of y^{t+1}_{RE}, this quantity vector would maximize revenues using inputs x^{t+1}, with the reimbursements per output given by p^{t+1} and with the sequential technology to the period *t+1*. Thus y^{t+1}_{RE} can be identified as a solution to a linear programming problem identical to (14), replacing the data (y^s, x^s, x^{ot}, p^{ot}) with the data (y^{s+1}, x^{s+1}, x^{ot+1}, p^{ot+1}).

In addition, we should identify vector y^E, which, together with y^t_{RE} and y^{t+1}_{RE} will allow us to determine the *activity effect* described in (10) and the *technical change* effect described in (11). Because y^E maximizes the revenues obtained using x^t, when the reimbursements on the regulated outputs are p^t and the sequential technology until period *t+1*. y^E can be identified as a solution to a linear programming problem identical to (14) in which the data (y^s, x^s, x^{ot}, p^{ot}) is replaced with the mixed data (y^{s+1}, x^{s+1}, x^{ot}, p^{ot}).

By solving each of the five linear programming problems defined by (13) and (14) *I* times, once for each distributing company in the sample, all the information required to identify the five output vectors is generated (y^t_{RE}, y^{t+1}_{RE}, y^C, y^D, y^E). When these are combined with the vectors of observed outputs (y^t, y^{t+1}) and with the unitary reimbursement vectors (p^t, p^{t+1}), the change observed in the total amount of standard costs ($CS^{t+1} - CS^t$), for each of the electricity distributing companies, can be decomposed into the six components shown by expressions (9), (10) and (11).

5. The Data

The data used in this study describe the distribution activities of the most important Spanish companies, which were those regulated by means of the MLE: Eléctrica del Viesgo S.A., Eléctricas Reunidas de Zaragozanas S.A., Fuerzas Eléctricas de Cataluña S.A., Hidroeléctrica Española S.A., Hidroeléctrica de Cataluña S.A., Hidroeléctrica del Cantábrico S.A., Hidroeléctrica Ribagorzana S.A., Iberduero, Iberdrola, Sevillana de Electricidad S.A. and Unión Fenosa S.A., from 1952 up until 1997. With this data we have built up an unbalanced panel, which includes 144 observations. This extensive period has been divided into two parts: 1988-1997, when the MLE was officially in effect, and which is the object of this study, and the period prior to this: 1952-1987. For this latter period, we have 61 observations, which we used to define the initial best practice technology.

As we have commented in the previous section, in order to design the revenues model that we intend to apply we have constructed sequential frontiers, by accumulating information from the year 1952 to the year 1987, and subsequently adding the data for every year up to 1997. We have therefore ensured that there is enough information to adequately construct each of the production frontiers for the period 1988–97. This will allow us to calculate the decomposition of the Bennet quantity indicator presented in expressions (10) and (11). It is impossible to apply the methodology of the Bennet indicators to the previous stage, 1952 – 87, since for this time we only have information on physical quantities but not for revenues per output.

The data has been obtained from various sources. Company records and the annual reports of the Ministry of Industry and Energy have provided us with information on the outputs supplied by the companies during the period 1952-1987, and on the inputs used for the whole period, 1952-1997. The data on outputs for the period 1987-1997 and the total sums paid by the regulator in the aforementioned period has been obtained from the detailed annual reports drawn up by the now defunct "*Oficina de Compensaciones de la Energía Eléctrica*" (OFICO). This information has recently been published by Red Eléctrica de España (2006).

Defining the quantities of outputs and inputs

As for the choice of the variables to include in the model, there are two aspects that condition this. Firstly, the regulatory framework: the object of study is the MLE, which, as we have seen, defines some outputs upon which it bases its reimbursement system. This set of four outputs, discussed in Sub-section 2.1, is that which defines the outputs used in application, since the companies' revenues depend exclusively on these. However, we have certain informative restrictions due to the fact that part of the data corresponds to the period 1952-1987. The need to have information prior to the MLE's period of validity has forced us to aggregate the electricity delivered in high and medium voltage. This is because numerous changes in the tariff structure took place over this period, as well as to its nomenclature. Consequently some concepts were at one time considered high-voltage and at another medium voltage, thereby preventing uniformity in the series. Hence the outputs and the inputs used in application are the following:

Outputs:
(i) Number of subscribers that each distributor supplies, expressed in millions.
(ii) Electricity delivered at high and medium voltage, expressed in Gw/h.
(iii) Electricity delivered at low voltage, expressed in Gw/h.

Inputs:
(i) High voltage distribution lines (between 36kv and 132kv), expressed in kilometers.
(ii) Medium voltage distribution lines (between 1kv and 36kv), expressed in kilometers.
(iii) Low voltage distribution lines (< 1kv), expressed in kilometers.
(iv) Transformer capacity from high to high voltage, and from high to medium voltage; and additionally, transformer capacity from medium to low voltage, expressed in MVA.

It would have been interesting to include work as an input. However, historically, the electricity companies were integrated vertically, making it impossible to obtain the specific data for the distribution activity[23]. In addition, it was not thought suitable to introduce quality of service as a variable since: i) as indicated in Section 2, the reimbursements that the companies received did not depend on the levels of quality attained; ii) the data available on the quality of the service for the period 1988-1997 presents serious doubts regarding its construction and comparability between companies. We shall return to these aspects in the next section, when we discuss the results.

In order to check the reliability of the data compiled before applying it, an analysis was carried out aimed at detecting possible *outliers*. For this we applied the method proposed by Fox et al. (2004). This method allows the detection of outliers due both to the scale of the observation and to the combination of the inputs used. In the database used, no observations were detected that might be considered extreme in either of the two senses. This means that, although the previously defined models of mathematical programming are deterministic, we know that they are applied to data that behaves correctly.

Defining the reimbursement of the outputs

With regard to determining reimbursements, we have already seen throughout this study that the MLE reimburses the companies for their standard costs. Thus, the reimbursements for an output derive from the aforementioned costs, which are in turn the ones that determine their revenues[24]. The method use to determine the reimbursements for each of the outputs was the following: i) the price of the output *number of subscribers* was determined by means of the quotient between the standard commercial costs recognized by the regulator for this concept and the number of subscribers; ii) we defined the price corresponding to the output *energy distributed in high and medium voltage* by taking as a reference the total standard costs (fixed and operating) that the MLE allocates to these activities. The sum of these costs divided by the number of GW/h distributed in those voltages gives us the price of the output; and (iii) similarly, we determined the price for the output *energy distributed in low voltage*, as the quotient between the sum of the fixed and operating standard costs and the number of Gw/h distributed in low voltage.

Statistics of the variables

Table 2 displays the statistics of the average data for the variables included in the model during the period analyzed, 1988-1997. Several considerations need to be taken into account when observing this data. Firstly, that there is a major dispersion in the sizes of the companies included in the sample. Secondly, we should point out that the merger between Iberduero and Hidroeléctrica Española that took place in 1991, which gave rise to Iberdrola, changed the structure of the sector significantly. This is mainly because it contributed to a substantial increase in concentration, as these two were the largest companies in 1990. This means that the increase between 1990 and 1991 observed in the statistics of the average company between these years is simply due the fact that the quantities were distributed among fewer companies. Both for the outputs and for the inputs, we see that all variables grow, on average, in all the years. As for the inputs, it is worth stressing that some of the most significant variations seen in Table 2 may reflect exchanges of assets between companies or operations between the companies and REDESA, the public high voltage transport corporation[25]. It should also be noted that the average number of subscribers grew for all the years considered, except 1994, with a decrease due to asset exchange[26]. Lastly, when analyzing the statistics for the unit reimbursements we see that important variations exist over the whole period for all the outputs, especially for high-voltage, which simply reflect the changes produced in the legislation (see Table1). The consequences of these changes will be analyzed in detail in the next section.

Table 2
AVERAGE STATISTICS FOR SPANISH ELECTRICITY DISTRIBUTION COMPANIES: 1988-1997

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
OUTPUTS										
y_1 Subcribers (millions)	1.98	2.03	2.07	2.48	2.51	2.55	2.51	2.55	2.59	2.64
y_2 Electricity (AT+MT) (GWh)	7,498	8,041	7,807	9,683	9,692	9,451	9,368	9,971	9,937	10,566
y_3 Electricity (BT) (GWh)	5,498	6,072	6,411	8,036	8,241	8,375	8,566	8,693	9,156	9,331
INPUTS										
x_1 Km AT	5,949	5,967	5,980	6,952	7,035	7,084	7,103	7,162	7,300	7,397
x_2 Km MT	18,038	18,522	19,398	23,373	23,935	24,288	25,070	25,664	27,075	27,530
x_3 Km BT	24,498	25,142	26,366	31,329	32,408	32,914	33,731	34,649	35,362	36,035
x_4 Capacity (MVA)	19,428	19,869	20,691	24,500	25,523	24,944	24,860	25,503	26,732	27,500
PRICES (current €)										
p_1 Subcribers	16.69	17.49	18.61	19.47	20.48	18.72	19.51	22.06	21.44	26.84
p_2 Electricity (AT+MT) (c€)	1.61	1.69	1.88	1.95	2.12	2.19	2.19	2.28	2.31	2.24
p_{Y3} Electricity (BT) (c€)	0.86	0.90	0.94	0.98	1.02	1.05	1.09	1.14	1.15	1.15

6. Results

The results obtained after applying the model are set out in Tables 3 and 4. When presenting them, we followed the approach taken by Försund and Hjalmarsson (1979) who propose studying an industrial sector by defining an ‘average’ company that they consider representative of the sector. We can see that in the methodological context defined in this study, characterized by a Bennet indicator, the ‘average’ is the arithmetical one. Försund and Kittelsen (1998) use this approach to analyze the behavior of Norwegian electricity distribution, and Arozena and Waddams Price (2002) for the case of electricity generation in Spain. Thus, the results presented below refer to the average electricity distribution company. In addition, the results calculated for the case of the average company, expression (9), multiplied by the number of companies, are equal to those of the sector as a whole. Furthermore, Fox (2006: 80) shows that using the average company allows a Bennet indicator to be made transitive, a property that makes it possible to make multilateral comparisons between companies. We have not employed this property in this study.

Table 3
DESCOMPOSITION OF THE AVERAGE COMPAN'S REVENUE CHANGE PER OUTPUT: BENNET PRICE AND QUANTITY INDICATORS
(millions of current euros)

	1989-88	1990-89	1991-90	1992-91	1993-92	1994-93	1995-94	1996-95	1997-96	1997-88
Revenue Change	**25.26**	**18.79**	**17.58**	**25.06**	**2.11**	**4.19**	**35.78**	**7.95**	**23.84**	**17.84**
Reimbursement Effect	**10.37**	**19.23**	**10.46**	**22.10**	**5.22**	**4.75**	**19.99**	**2.43**	**6.29**	**11.20**
p_1 Subcribers	1.60	2.31	1.71	2.51	–4.45	2.00	6.44	–1.60	14.16	2,74
p_2 Electricity delivered (AT+MT)	6.45	14.39	6.73	16.42	7.04	–0.03	8.84	2.99	–0.01	6.04
p_3 Electricity delivered (BT)	2.31	2.80	2.03	3.17	2.63	2.79	4.71	1.04	0.31	2.42
Bennet Quantity	**14.90**	**–0.43**	**7.12**	**2.96**	**–3.11**	**–0.57**	**15.79**	**5.52**	**17.55**	**6.64**
y_1 Subcribers	0.87	0.63	0.46	0.72	0.70	–0.78	0.87	0.99	1.21	0.63
y_2 Electricity delivered (AT+MT)	8.99	–4.18	2.33	0.19	–5.20	–1.83	13.50	–0.78	14.32	3.04
y_3 Electricity delivered (BT)	5.05	3.12	4.34	2.05	1.39	2.04	1.42	5.30	2.02	2.97

The first thing that the results in Table 3 reveal is that the standard costs associated with the distribution activity grew every year from 1988 to 1997. This growth trough was not uniform due to the changes that occurred in the legislation and in the economic situation in the country throughout the period. On average, the average company's yearly growth in revenues was somewhat higher than 6.5%. In absolute terms, this means an average increase of 17.84 million euros. Once this first approach was completed, we proceeded to analyze the decomposition of the difference in revenues between a Bennet reimbursement indicator and one for quantity described in expression (9). We observed that for most years the Bennet reimbursement indicator contributed to a greater extent to the obtaining of revenues than the quantity indicator, apart from the years 1988-1989, 1995-1996 and 1996-1997. The proportion was around 62% and 38% respectively, for the average of the period.

The Bennet Reimbursement Indicator

In an analysis of the Bennet price indicator by output we see that, in most years, the output that contributed most to the obtaining of revenues has been energy in high and medium voltage, with an average increase of over half the variation observed in the reimbursement. This fact is especially noteworthy before 1993, the date of the first significant modification of the MLE (see Table 1). In fact, this first revision of the MLE divides the study period into two clearly differentiated sub-periods: that of 1988-1992, and of 1993-1997.

Of this aggregated output, high voltage plus medium voltage, we can say that the contribution of the Bennet indicator to high-voltage reimbursements was higher than that for medium voltage, in a proportion of approximately 70% to 30%. This seems logical when we look at the legislation, since the regulation in medium voltage was fairly closed in all its facets, as pointed out in Sub-section 2.1. In contrast, the modifications in the reimbursements of high-voltage were frequent, for two main reasons: i) the variation, on several occasions, that the criterion for calculating the rate of return on capital, which is reflected in the results; ii) the increase in the standard costs recognized. It should be remembered that we have calculated the reimbursement associated with these voltages as the quotient between the standard costs paid and the energy distributed. The increase in the numerator, standard costs, was produced basically due to the recognition of new high-voltage facilities, and especially transformer substations, since the standard costs for these facilities are calculated in terms of physical units and not of circulated energy. For the system as a whole, there was an increase of 23.23% in transformation capacity for the period 1988-1992, signifying a yearly growth rate of approximately 5.4%. If we look at the results per company, we can see that of the four companies with highest growth in substations, three of them correspond to those that have the highest proportions of energy supplied over the whole of the system. In contrast, the increase in transformation capacity is only 4.56% for the whole period 1993-1997, signifying a yearly growth rate of a little over 1%. This result suggests that the incentive for recognizing new standard costs associated with high-voltage practically disappeared with the revision of the MLE carried out in 1993.

Given these results, we believe that the MLE introduced incentives for companies to bring investments forward, i.e. by putting facilities into operation, specifically substations, which according to the forecast demand would not be needed until well into the future. As we shall see, this behavior affected the efficiency and productivity levels of distributors, since they put into operation facilities that were used beneath the levels considered optimum. This aspect had a positive side-effect, which was the increase in the quality of the service, especially over the 1988-1994 period, in which the economic incentives associated with improvement were non-existent, as we have seen in Sub-section 2.1. Lastly, we can see from this analysis of the reimbursement effect that in the 1988-1992 period the increases in reimbursements for high and medium voltage were higher than the rates of inflation.

This result does not corroborate the theoretical conclusions about the MLE arrived at by Laffont and Crampes (1995). These authors drew up their model assuming that the outputs associated with distribution were identically regulated, coming to the theoretical conclusion that the level of *ex-ante* effort associated with investment would be less than the optimum one. However in this study we noticed that companies had an incentive to over-invest during the period 1988-1992, since it was a way of increasing revenues by means of higher standard costs. We shall return to this aspect in the Conclusions to the study. Lastly, regarding high and medium voltage energy, it should be pointed out that the strong negative contribution for the period 1996-97 is due to the drop in inflation in Spain, falling from 3.6% in 1996 to 2% in 1997, which led to a reduction in the reimbursement for both high and medium voltage, since both were linked to this index. In particular for medium voltage, on discounting 3% from the RPI in the updating of operating costs in 1997, this update became negative.

The contribution of low voltage to the increase in standard costs was somewhat higher than 20%, and the *number of subscribers* close to 25%. As for the *number of subscribers*, Table 3 shows the variations caused by the contradictory legislative revisions of 1993, 1995 and 1997 already mentioned in Sub-section 2.1. Table 3 shows the considerable decrease represented by the 1993 revision, which was followed by those of 1995 and 1997. These later revisions were associated with increases that were much higher than the inflation rate for the period. Thus we see that the negative high and medium voltage reimbursement effect for these years is seen to be compensated by the number of subscribers, due to the reform in which an incentive for demand management was added to these costs.

The Bennet Quantity Indicator

Decomposition per variable

In Table 3 the analysis of the quantity effect shows us that its progress is closely linked to the country's economic situation, and more specifically to industrial activity. One of the most stable outputs in Table 2 is the number of subscribers, being the one that contributes least to the quantity effect, representing on average 9.5% of the observed revenues increase. Low voltage energy is also revealed to be relatively stable, contributing 45% to the total average increase. Its progress reflects the sustained increase in low voltage consumption by households. For its part, the contribution of energy distributed in high and medium voltages is somewhat higher than that of low voltage. However, it is the output that suffers most alterations throughout the period, which is quite logical if we consider that industrial activity is much more sensitive to the ups and downs of the economic situation. Thus we can see how the periods of deceleration of the Spanish economy are reflected in the years 1989-90, 1992-93, 1993-94 and 1995-96. We shall continue by examining the Bennet quantity indicator from another perspective, in terms of the decomposition displayed in Table 4, which sets out the methodology presented in Sub-section 3.2.

Economic Decomposition

Table 4 shows us that the factor that has contributed most to the Bennet quantity indicator has been the a*ctivity effect*, which measures the potential that the availability of a greater quantity of inputs has meant in terms of generating new revenues. We have calculated that the average potential growth of new revenues associated with greater availability of facilities is 12.54 million euros. However, this potential was drastically reduced by the continual losses of productivity observed during the period, and which, on average, meant a decrease in revenues of 5.91 million euros. The sum of these two distant values makes the average value of the Bennet quantity indicator 6.64 million euros. In the same way, Table 4 reveals that the fall in productivity was caused fundamentally by a loss of operating efficiency which, as we can see, deteriorated dramatically in most years, and especially during the period 1988-1994. The individual results for the distribution companies do not show a different behavior to that for the average company.

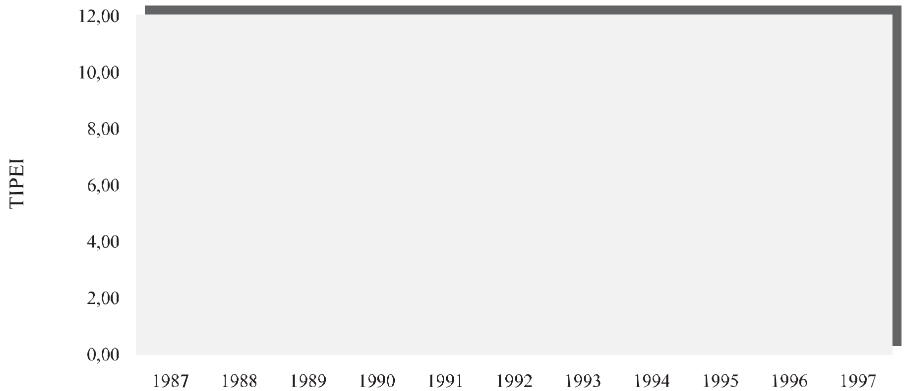
Table 4
DESCOMPOSITION OF THE QUANTITY BENNET INDICATOR, AVERAGE COMPANY
(millions of current euros)

	1989-88	1990-89	1991-90	1992-91	1993-92	1994-93	1995-94	1996-95	1997-96	1997-88
Quantity Bennet	**14.90**	**–0.43**	**7.12**	**2.96**	**–3.11**	**–0.57**	**15.79**	**5.52**	**17.55**	**6.64**
Activity Effect	7.60	15.32	19.43	16.53	2.45	8.56	14.36	16.13	12.46	12.54
Productivity Effect	7.30	–15.75	–12.31	–13.57	–5.56	–9.13	1.42	–10.61	5.08	–5.91
Technical Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Operating Efficiency	3.20	–9.34	–9.27	–10.52	0.75	–10.21	–4.26	–5.39	3.32	–4.64
Allocative Efficiency	4.10	–6.41	–3.05	–3.05	–6.30	1.09	5.69	–5.22	1.76	–1.27

Crampes and Laffont (1995) came to the conclusion that, in an *ex-post* situation, the MLE provided incentives for companies to operate efficiently, i.e. to maximize the output-inputs ratio. They considered that this result could become distorted for two reasons: i) if mergers or takeovers took place and the industry concentration rose; ii) if the agent, upon choosing its level of effort, knew (or suspected) that standard costs would be adjusted downwards to embrace the reduction of real costs associated with operating efficiency. For these authors, because the MLE did not contemplate any pre-established reviewing procedures, and it was unlikely that standards costs would not be reviewed, the theoretical result of analysis could be seen to be altered.

It is possible that the sector's concentration helps to explain the results of the persistent deterioration in operating efficiency. This is because, as we have seen, the two biggest companies in the sector merged: Hidroeléctrica Española and Iberduero. On the other hand, we believe that the method of revision must have played an important role, and that the MLE was, from 1993 onwards, the object of almost yearly revision (see Table 1). However, in our opinion the main cause explaining the negative levels of operating efficiency is the behavior of the companies, which was aimed at increasing the standard costs recognized for high voltage by putting new facilities into operation[27, 28]. We have already commented that we believe that companies brought investments forward. Investments which, according to the evolution in demand, should have been made later if the aim was to use them at a suitable capacity. The decline in operating efficiency, especially in the 1988-1994 period, reflects a fall in the input-output ratio.

As we have seen in Sub-section 2.1, the quality of the service was never one of the regulator's objectives. In 1994, for the first time, a timid reimbursement was made for investments aimed at improving the quality of the medium and low voltage supply. This incentive was later withdrawn in the revision of the electricity system carried out in 2000. We have calculated that the revenues obtained by the companies for quality improvement represented 0.7% of the total in 1994, and 1.1% annually in the 1995-1997 period. However, everything seems to indicate that this improved notably during the MLE, and especially in the 1988-1994 period. The quality of the supply has historically been measured in Spain by the Installed Power Equivalent Interruption Time - *Tiempo de Interrupción Equivalente de la Potencia Instalada*" (TIEPI), defined by the ratio between the medium and low voltage electricity distributed and the distributed medium and low voltage electricity lost due to unplanned interruptions. The lower the TEIPI, the higher the quality of the service. Graph 1 shows the progress of the TIEPI for the average company from 1987 to 1997. We can see that the TIEPI went from 9.70 in 1987 to 3.88 in 1994, and finally to 3.25 in 1997. We are thus faced with a rare case of positive externality. Although the economic incentive aimed at improving the quality of the supply was practically non-existent, this improved with the operationalization of new facilities whose main aim was to increase revenues, i.e. the standard costs recognized by the regulator. UNESA (1997) also considers that the most influential factor in the observed increase in quality was the high investment in transport and distribution facilities made by the electricity companies throughout this period.



Graph 1. Service quality evolution for the average company

The TIEPI results in Graph 1 should be considered indicative. López (2006) points out that the TIEPI data supplied by the companies was never audited, and that there is no guarantee that these were calculated using a procedure that was homogenous in time and between them. Under these circumstances, there is no guarantee that the TIEPI results supplied by the companies were an objective reflection of the real supply rather than a figure used in their own interest. Despite this, everything seems to indicate that quality improved, especially in the period from 1988 to 1994.

It should also be stressed that during the period that the MLE was in force there was no movement of the best practice production frontier, i.e. no technical change took place. As we have explained in Sections 3 and 4, in this study we have used a sequential-type technology. In this type of technology the information accumulates, and is never lost. For the production possibility frontier to move would require new observations so as to have a better output-input ratio than the preceding one. If this does not occur, there is no technical change. As companies put into operation facilities that were not initially used at their optimum level, this ratio worsened during the 1988-1997 period. This is the reason we did not observe technical change, whereas we did observe operating inefficiency. It is to be expected that we should observe movements at the production frontier, i.e. technical change, when the increase in demand causes the new facilities, put into operation mainly during the1988-1994 period, to be used with greater intensity.

Lastly we have to report that to the loss of operating efficiency must be added, in over half of the observed years, a loss of allocative efficiency in distribution activity. However, on average this negative effect is much lower than that for operating inefficiency. Nevertheless, allocative efficiency deserves special interest insofar as it may be a direct consequence of the system of reimbursement established by the MLE, in the sense that the companies have a limited capacity to manage their markets. It is therefore the regulator who is responsible for providing the companies with a price mechanism that reflects the relative demand for electricity. As we have seen throughout this study, the regulator changed some of the compensations in a contradictory way. Therefore, to the MLE's aforementioned weaknesses and regulatory failures, we should now add an inability to create a system of relative incentives that was close to the demand structure.

7. Conclusions

In this study, we have analyzed the regulation of the Spanish electricity system in force between 1988 and 1997 for the activity of electricity distribution, known as the Marco Legal Estable (MLE). This system of incentives, developed in a complicated legal framework throughout the ten years of its validity, is not easy to classify.

The analysis of the MLE for the activity of electricity distribution has been carried out in a dynamic and multi-output context. This was done using a new economic model based on a Bennet revenues indicator, which has allowed us to study, over time, the behavior of each of the regulated products. Using this approach, we have introduced and analyzed the idea of 'partial' renegotiation, in the sense that the companies have not sought an overall renegotiation of the system of regulation, as many theoretical models assume. Rather, they have exploited the weaknesses of the system by identifying and applying pressure to its weakest points, which only affect partial and apparently unimportant aspects of the regulatory system. In our opinion, the Achilles' heel of the MLE was the regulation of high-voltage facilities, where everything seems to indicate that, up until the first review in 1993, the electricity companies obtained substantial and sustained increases of revenues by negotiating the rates of return on high-voltage investment and the recognition of new facilities, specifically, sub-stations. The remuneration for these facilities was not associated with their use, but merely with their existence. This situation was encouraged by the fact that it was the regional government that approved the new facilities, while it was the Ministry of Industry and Energy which provided the reimbursements for them. The exploitation of this partial weakness of the regulatory system led the companies to engage in a behavior aimed at obtaining new forms of revenues, i.e. the recognition of new standard costs. Thus the companies were given an incentive to bring forward investments, such as put into operation facilities which, according to the forecast demand, would not be needed until well into the future. This has led to a systematic and sustained loss of productivity in the sector, due basically to an over-capacity in certain inputs. However, with the first reform of the MLE in 1993, the economic incentives to invest in facilities practically disappeared, thereby slowing down the companies' rate of investment. This, together with the uninterrupted growth in demand, may be the reason why there is currently no talk of over-capacity in the sector but of lack of investment in electricity distribution.

Another aspect we would like to highlight is that everything seems to indicate that the quality of the service improved ostensibly during the MLE, especially in the period from 1988 to 1994. This fact should be interpreted as a positive side-effect of the implementation of the new facilities. This improvement in the quality of the service in fact constitutes a rare case of positive externality, since the first timid economic incentive to improve quality was introduced in 1994. Quality has always been a secondary objective for the regulator. The economic incentive provided by this concept represented only about 1% of the companies' total revenues, and was withdrawn with the revision of the Spanish electricity system carried out in 2000.

The regulator changed the criteria for reimbursing high-voltage in 1993, but in subsequent years, modified the reimbursement for other products that had made a more modest contribution to the electricity companies' increases in revenues. It is curious to observe the contradictory way that the regulator changed the reimbursement for the product "number of subscribers". The reimbursement for this item was adjusted downwards in 1993, only to be increased markedly in 1995 and 1997 so that this compensated to a large extent for the loss of revenues associated with the reviewing of high medium and low voltages. The behavior described may reveal a real instance of the distributing companies influencing the regulator, although this aspect should be the object of further research.

In addition, we found that no movement of the best practice production frontier took place during the period that the MLE was in force, i.e. no technical change took place. This result agrees with that described above, since in order for there to be technical change, the output-input ratio needs to be better than the preceding ones, and this condition cannot be fulfilled when the new facilities are not initially used at their optimum level. In addition, the high levels of allocative inefficiency suggest the regulator was incapable of providing the companies with a reimbursement mechanism that reflected the relative demand for electricity.

Finally, we would like to stress that the results of our empirical research seem to coincide very little with Crampes and Laffont's theoretical results (1995). These authors created a model for the MLE, and believed that it could be considered some kind of yardstick competition in which reimbursement based on the average costs of the sector was replaced by standard costs. However they warned that this change introduced by the Spanish regulator in fact meant abandoning the anonymity of the yardstick system, and allowed the possibility of the costs recognized and paid for by the regulator might be manipulated by the company. To avoid this possibility, they pointed out that an extremely strict control of the regulation system was needed, together with clearly established procedures in the reviewing and updating systems. Throughout this study we have provided ample evidence that the recommendations made by Crampes and Laffont were not complied with. It is not therefore surprising that there is little agreement between the behavior of the parties involved that was theoretically predicted by these authors and the empirical results found in this study.

Notes

1. In fact, Electricity Law 40/1994 was enacted in 1994, however the majority of its proposals were never put into force.
2. In the "White Book on the regulatory framework of electricity generation in Spain" by Pérez Arriaga (2005) we can read: "(…) wish to point out here the absence of a procedure for remunerating the activity of distribution that responds to even the most elementary regulatory principles: an individualized treatment of the companies and association of the remuneration to the level demanded by the quality of the service and to the investments needed and carried out. The Spanish procedure for remunerating the activity of distribution is clearly one of the most deficient in the international context". (Page 67, Note 48). Similarly, the CNE has indicated on numerous occasions that it is still necessary to justify the retributive recognized base to the activity of distribution, which the applicable ground rules have not resolved. See, for example Report 16/2002 or the CNE's Report 7/2004.
3. In fact, for those distributors who carried out their activity under the MLE, the ESL took that existing up until 1997 as the basis for their reimbursement.
4. See, for example, Report 23/2007 concerning the Royal Decree proposal for regulating the activity of electrical energy distribution, drawn up by the CNE.
5. In the context of this study, we cannot assume duality between the production function and that of costs, since the duality is fulfilled under highly restrictive conditions (Grifell - Tatjé (1990)).
6. Other studies that have used the DEA to analyze electricity distribution are: Hjalmarson and Veiderpass (1992 a,b) Pollit (1995), Bagadadioglu, Price and Weyman-Jones (1996), Zhang and Bartels (1998), Forsund and Kittelsen (1998).
7. For a view of the contemporary and legal background of the MLE, see for example Ontiveros (1986), San Pedro (1986), and Ariño and López de Castro (1998).
8. A system was established for correcting deviations, which, due to their relevance, may have a bearing on the companies' revenues as a consequence of the provisional character of the parameters and values that have been used to calculate the rate. The M.O. of December 19th 1988 indicated what these parameters were and described under what terms the corrections were made.
9. For a more detailed analysis of the calculation of the reimbursement rate, we recommend Rojas (1994).
10. In the event that the facility only affected the region which is called "Autonomous Community". See Article 149 of the Spanish Constitution.
11. In both cases, the standard costs were established by differentiating three voltage ranges: (i) 36 kV≤Voltage< 72.5 kV; (ii) 72.5 kV≤Voltage <145 kV; y (iii) 145 kV≤Voltage.

12. The energy circulated at a voltage level is defined as the aggregate of the energy distributed to the end users at this voltage level and that distributed at lower voltage levels, affected by a loss factor.

13. Medium voltage is considered that between 1 kV and 36 kV; with low voltage being considered that below 1 kV.

14. $CBT_t = CBT_{(t-1)} * [1 + (0.75 * (0.5 * RPI + 0.5 * IPPI))]$
$CMT_t = CMT_{(t-1)} * [1 + (0.75 * (0.5 * RPI + 0.5 * IPPI))]$

where: CBT_t: standard fixed unit costs at low voltage for the period *t*; $CBT_{(t-1)}$: standard fixed unit costs at low voltage for the period *t-1;* CMT_t: standard fixed unit costs at medium voltage for the period *t*; $CMT_{(t-1)}$:are the standard fixed unit costs at medium voltage for the period *t-;*. RPI: retail price index, and IPPI: industrial product price index.

15. $CBT_t = CBT_{(t-1)} * [1 + (0.75 * (0.5 * RPI + 0.5 * IPPI))]$

where (0.5 * RPI + 0.5 * IPPI) is an index of adjusted prices, which we shall refer to as IP.

$CBT_t = CBT_{(t-1)} * [1 + 0.75 * IP]$

Re-ordering the previous expression, we have:

$$\frac{CBT_1}{CBT_{t-1}} - 1 = [1 + 0.75IP - 1] = 0.75IP, \quad \frac{CBT_t - CBT_{t-1}}{CBT_{t-1}} = (1 - 0.25)IP = IP - 0.25IP, \quad \frac{CBT_t - CBT_{t-1}}{CBT_{t-1}} = IP - X$$

where X = 0.25*(0.5*RPI + 0.5*RPI)

Similarly, we would obtain the previous expression for medium voltage. Thus the regulation of the fixed costs for low and medium voltages applies the price cap criteria and introduces a discount factor of 25%, although the legislation does not specify it clearly in this way.

16. $C_{gcd} = \psi * N_a * CN_a + (1 - \psi)P_c * CP_c$

where: C_{gcd}: standard cost of commercial management of the system; y: unit adjustment coefficient for the number of subscriber policies, N_a: standard number of subscriber policies in the system; CN_a: standard cost in pesetas per subscriber policy; P_c: standard power subscribed at voltages equal to or higher than 1 kV, in Kw; CP_a: standard costs of power subscribed in pesetas/kW.

17. In the literature dealing with regulation, these monetary adjustments are usually referred to as "transfers". Here we have used the term 'compensations' since this is the term used by the MLE legislation.

18. In the M.O. December 22nd 1988, the Administration published the updated values (dated December 31st 1988), of the standard gross and net values added to December 31 1987 and the provisional ones to December 31st 1988, for each of the high voltage distribution facilities that were in service at that time and that would have entered into service prior to January 1st 1988. This evaluation was performed using the information sent by the various sub-systems and refers to the technical characteristics of the facilities and the date they are put into service.

19. The revenues are defined by the standard costs recognized by the regulator (Expression (2)). However, due to the correction set out in Expression (4), these may experience a certain variation depending on whether the company collects a higher or lower quantity than that calculated using the average rate for the sector. The per-product decomposition of this correction is not available, which is why it has not been taken into account in the application. However, the total amount collected by the company and that calculated with the average rate for the sector (Expression (4)) cannot be considered especially significant, and we believe that it would not alter the results and conclusions of the study substantially. To give an idea of the magnitude of this deviation, in 1989 the smallest deviation in absolute terms was 0.02%, while the company that incurred the largest deviation did so with 2.0%; for its part, in the last year that the MLE was in force, 1997, the interval was between 0.11% and 2.4%.

20. The decomposition of Expression (10) is based on the technology of the period $t+1$, as reflected in Figures 1 and 2. It is possible to accomplish an alternative decomposition to (10) using the technology of period *t*. This opens up the possibility of decomposing the *activity effect* using the arithmetical mean of the two decompositions.

21. The HV deserves a separate mention where, as we have seen in the Section 2.1, the standard costs recognized are based mainly on physical units such as, for example, transformation capacity. However, the amount collected by the distributing company from its customers is based on the electricity consumed.

22. These programs were developed by Färe, Grosskopf and Lovell (1985).

23. In addition, due to outsourcing by the electricity companies, there is a tendency to not consider the work factor as an isolated input. This means defining the costs associated with maintenance and the work factor as input. Due to vertical integration, this quantity had to be allocated between generation and distribution for each of the electricity companies, an allocation that seemed to us to be arbitrary. Moreover, this would have meant defining an input in monetary terms whereas the other outputs and inputs are defined by physical quantities.

24. The structural costs have not been included because they only appear in the series from 1993 onwards.

25. Although we used the information regarding transformation capacity in an aggregate way, we appreciate that a part of it corresponds to the transformation of electricity from high to high voltage and high to medium voltage, and that which corresponds to the transformation of medium to low voltage. The first of these, performed at substations, represents a percentage greater than 70% of the installed transformation capacity, whereas the remaining 30% is attributed to the transformation of medium to low voltage, performed in what are know as transformation centers (TCs).

26. This took place after the exchange of assets between Endesa and Iberdrola. In mid 1994, the merger was approved between Iberdrola and Hecsa, a company in which Iberdrola had a 96% holding. However, prior to this, in March, HECSA-I was created, to which the assets and liabilities pertaining to HECSA's distribution activity were transferred. HECSA-I was integrated into Enher and thus went on to form a part of the Endesa group. In this way Enher (Endesa) ended up with 55% of Hecsa and Iberdrola with 45%.

27. This is not the case in the situation of medium and low voltage facilities. An attempt was made to modify this situation with the reform carried out in 1993, which provided incentives for investments in medium and low voltage. It is unlikely that there was any kind of inefficiency in this type of facility, since the legislation did not provide incentives for there to be any, as it paid them for their effective use and not for their mere existence.

28. The fact that companies made good use of the weaknesses of the regulating system to increase their revenues by means of over-investment is not a new result in literature. Averch and Johnson's model (1962) predicts this behavior. In fact, when a company is regulated by the rate of return method, its revenues depend exclusively on the level of investment, regardless of its use. As we have seen, this was one of the characteristics of the regulation in high voltage in the case of the MLE.

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Resumen

El Marco Legal Estable nos proporciona una rara oportunidad para estudiar un sistema de retribuciones multiproducto aplicado a la distribución de electricidad en España durante un dilatado periodo de tiempo: 1988 – 1997. Para ello, se propone una estructura de análisis basada en un indicador del tipo Bennet (1920) que nos permite identificar las variaciones en los ingresos asociados a la actividad de distribución eléctrica, para cada una de las empresas y cada uno de los productos. La Ley reconocía, regulaba y retribuía de forma diferente a cuatro productos. Este indicador es descompuesto en un efecto cantidad y un efecto retribución. El efecto cantidad valora el impacto sobre los ingresos de las variaciones en la demanda de cada uno de los productos, y el efecto retribución las modificaciones en los ingresos debidas a los cambios en la remuneración por producto, que están basados en costes estándares. Utilizando la moderna teoría de la producción se explica el indicador de cantidad mediante un efecto productividad y actividad. Finalmente, el indicador de productividad es descompuesto en eficiencia operativa, asignativa y cambio técnico. Para ello se define una tecnología del tipo secuencial cuya información empieza en el año 1952. Para resolver la descomposición económica propuesta son empleadas técnicas de programación matemática.

Palabras claves: distribución eléctrica, Marco Legal Estable, ingresos, indicador Bennet.

Clasificación JEL: L51, L94.