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Concentration measurement under cross-ownership. An application to the Spanish electricity sector

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DOCUMENTO DE TRABAJO 2002-06

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Aplicado

Concentration measurement under cross-ownership.

The case of the Spanish electricity sector

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September 15, 2002

Abstract

When major investors own shares in several firms in the same industry, the traditional approach to concentration measurement by the Hirschman-Herfindahl Index (*HHI*) fails to accurately reflect the level of competition in the market. To address this problem we derive a generalized *HHI* formula (*GHHI*) based on the investors' degree of control over each firm. We test alternative definitions of this control with actual data from the Spanish electricity sector and show that recent decisions in this industry, particularly the failed merge between the largest firms, *Endesa* and *Iberdrola*, could have been affected had the *GHHI* been used by the competition agency.

Keywords: Hirschman-Herfindahl index, cross-ownership, electricity industry.

JEL nos: L1, L4

* The authors acknowledge useful comments received from audiences at seminars held in the universities of Las Palmas, Vigo and Carlos III. The paper was presented at the EARIE Conference (Madrid, September 2002) and has also benefited from discussions with Antonio Estache and Claude Crampes, although the authors assume full responsibility for any remaining error. Mr. Campos' contribution has been partly financed by the Spanish Ministry of Science and Technology, CICYT Project SEC99-1236-C02-02.

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1. Introduction

One of the most widely accepted paradigms in industrial organization nowadays is that, under very broad market conditions, a significant increase in ownership concentration raises the likelihood that coordinated anticompetitive behavior may eventually emerge. Since anticompetitive conduct causes prices to rise and output to decline, thus reducing the economic welfare, most countries' antitrust laws explicitly consider that concentration measurement is a key factor in determining the degree of competition in a market.

A standard proxy for the degree of ownership concentration is the Hirschman-Herfindahl Index (*HHI*), defined as the sum of the squared market shares of the firms within an industry (Demsetz, 1973). Although the literature has criticized the use of *HHI* on a number of different grounds (excessively static, unfavorable weighting of smaller firms, too sensitive to market definition, unable to make quality distinctions, etc.) its strong theoretical support – deeply rooted in the Cournot oligopoly model – still makes it difficult to replace. There is, however, a less frequently examined criticism to the *HHI* that also lies in the core of the Cournot model. Received economic theory considers that investors decide the actions of the firms they invest their money on by solving a simple profit maximization problem for each firm. But, if major investors own shares in multiple firms in the same industry, cross-ownership effects may merge the competitive interests of the firms and move the market equilibrium closer to the monopoly solution. In the presence of cross-ownership, the *HHI* fails to accurately reflect the true level of competition in the market (Demsetz and Lehn, 1985).

Several authors have already proposed modifications to the Hirschman-Herfindahl index that capture the (anti)competitive effects of cross-ownership under specific scenarios for control.¹ In this paper, drawing on Maxwell *et al.* (1999), we derive a general *HHI* formula (namely, the *GHHI*) that admits a wide range of control specifications. Our generalized Hirschman-Herfindahl index requires a measurement of the exact degree of control exercised by the firm's shareholders. One natural candidate is the *Shapley value* (see Shapley, 1953, and Shapley and Shubik, 1954), which has been successfully used in some recent empirical studies (for example, Rydqvist, 1992, or Zingales, 1995). We also propose alternative definitions of control – for example, the number of votes in the board of directors – and discuss their relevance for the Spanish case. Our results show that *GHHI* is more capable of detecting anticompetitive effects of cross-ownership than the *HHI*. However, implementing the *GHHI* in practice requires more computation and data availability, particularly on the power-sharing rules within the firms.

The structure of the rest of this paper is as follows. Section 2 describes the theoretical background of concentration measurement, first deriving the traditional *HHI* formula from the standard Cournot oligopoly model, and then criticizing it under a cross-ownership scenario. Section 3 proposes a general Hirschman-Herfindahl index (*GHHI*), explicitly based on the investors' stakes in the firms. Section 4 discusses in detail how the *GHHI* can be implemented in practice under alternative definitions for control. Section 5 is devoted to the empirical application of the *GHHI* in the recent history of the Spanish electricity sector. Finally, Section 6 provides a summary of the major conclusions.

¹ For example, Reynolds and Snapp (1986) use a modified *HHI* in a special case of cross-ownership: when each firm has one sole controlling shareholder. Bresnahan and Salop (1986) analyze the impact of a joint-venture among competitors and quantify its competitive effects through a modified *HHI*.

2. Reviewing the theoretical background of concentration measurement

Business seller concentration refers to the extent to which sales in a market are concentrated in the hands of a few firms. At the level of a single industry, this concentration is thus an (imperfect) indicator of the degree of oligopoly, and measures thereof are widely used by industrial economists in empirical tests of oligopoly theory. The most popular operational measure is the Hirschman-Herfindahl index (*HHI*), which is the sum of squared market shares of all firms in the industry. This section briefly reviews the theoretical background of the *HHI*, showing its strengths as well as its weaknesses.

2.1. The Cournot-Nash equilibrium

As a benchmark, consider the standard Cournot-Nash oligopoly model with n independent firms selling homogeneous outputs, denoted by x_j for $j=1, \dots, N$. Total industry output is equal to $X \equiv \sum_j x_j$, and the corresponding market shares are given by $s_j \equiv x_j/X$. Let $p(X)$ be the inverse demand function for the market and define $\eta = (1/p'(X))(p/X)$ as the price-elasticity of demand (where $p' < 0$ represents the slope of the demand curve). Let $c_j(x)$ be firm j 's cost of output level x , so that $\pi_j \equiv \pi_j(X) = p(X)x_j - c_j(x_j)$ is firm j 's profit.

In a Cournot-Nash equilibrium firm j maximizes its expected profit conditional upon the output of the remaining firms, that is:

$$\max_{x_j} \pi_j = \max_{x_j} p \left(\sum_{i \neq j} x_i + x_j \right) x_j - c_j(x_j). \quad (2.1)$$

The Cournot-Nash equilibrium output for firm j satisfies the first order condition

$$p \left(1 - \frac{s_j}{\eta} \right) = c'_j, \quad (2.2)$$

where c'_j is marginal cost of firm j . Finally note that, of course, firm j 's Cournot-Nash equilibrium output is below its competitive equilibrium output in which $p = c'_j$, but above its monopoly output, in which $p(1-1/\eta) = c'_j$.

2.2. The Hirschman-Herfindahl index and its properties

The Hirschman-Herfindahl index, defined as $HHI \equiv \sum_j s_j^2$, is the most popular measure of concentration in antitrust analysis. If market shares s_j are defined in units of percentage points, the *HHI* in a market with a single monopolist is 1 (maximum). The *HHI* approaches $1/N$ as the number of firms grows large, assuming every firm's shares of the market declines proportionately (reaching in the limit $1/N$).² The *HHI* provides an ordinal measure of competition in a market even when the market is not divided equally among the firms. For example, a market equally divided among 3 firms has a *HHI* of $1/3$ and is considered less concentrated than a market with 4 firms and market shares 0.7, 0.1, 0.1 and 0.1, which gives an *HHI* of slightly more than $1/2$.

² The US Federal Trade Commission and many other competition agencies around the world make an explicit use of the *HHI* (although pre-multiplied by 10,000). In the 1992 US Merger Guidelines it is stated that (p.11): "(...) the Agency will use the Hirschman-Herfindahl Index of market concentration. The Agency divides the spectrum of market concentration as measured by the *HHI* into three regions that can be broadly characterized as low-concentrated (*HHI* below 1,000), moderately concentrated (*HHI* between 1,000 and 1,800), and highly concentrated (*HHI* above 1,800).

The wide reliance upon the *HHI* lies in its strong theoretical support. There is a direct correspondence between the *HHI* and the industry average price-cost margin (the Lerner index) arising in a Cournot-Nash equilibrium. To check this, first rearrange the terms of equation (2.2) so that the left-hand side becomes the firm's price-cost margin, L_j , and the right-hand side is the firm's market share divided by the elasticity of demand:

$$L_j \equiv \left(\frac{p - c'_j}{p} \right) = \frac{s_j}{\eta}. \quad (2.3)$$

Now calculate the industry-wide Lerner index (denoted by L) as the market-share weighted average price-cost margin:

$$L \equiv \sum_j s_j L_j = \sum_j s_j \left(\frac{p - c'_j}{p} \right). \quad (2.4)$$

Finally, a simple substitution gives the relationship between the Lerner index and the *HHI*:

$$L \equiv \sum_j s_j \left(\frac{p - c'_j}{p} \right) = \frac{1}{\eta} \sum_j s_j^2 \equiv \frac{H}{\eta}, \quad (2.5)$$

a fairly standard result, commonly presented in textbooks on industrial organization, that relates price-cost margins to concentration.

In calculating the *HHI* there are, however, a number of well-known drawbacks often based on being excessively static, giving unfavorable weighting of smaller firms or being too sensitive to market definition.³ In most cases, the firms' relative sizes are frequently measured using current revenues. While this approach is useful and easy to apply in many contexts, it also has limitations. Thus, assigning a low weight to firms that have relatively low revenues may understate the importance of such firms in disciplining potential anticompetitive behavior. A small firm that can expand its output rapidly may have an importance in deterring other firms from raising price that is far more than proportional to its current size. Furthermore, if there is significant volatility in firms' revenues, relying on current revenues will tend to overstate concentration. For instance, a market may appear concentrated if some firms have unusually high revenues and other firms unusually low revenues in a given year. Over a broader period less subject to random fluctuations, firms would be correctly viewed as more nearly equivalent in size, and calculated concentration would be lower. The solution may lie in calculating *HHI* using capacity rather than current revenues, but this is not always possible.

In general, all these criticisms are relatively easy to tackle with suitable minor amendments. But there is one disadvantage of *HHI* that requires more changes. In particular, the Cournot-Nash model treats the firms as independent entities, each maximizing its own profit without regard to the effect on other firms' profits. This makes sense if each firm is owned by a separate group of investors, or possibly if investors are a diffuse class and the management of each firm is distinct. However, if major investors own shares in a number of ostensibly competing firms, the assumption of independence may be cast into doubt. The only sensible alternative is to re-develop the Cournot model explicitly acknowledging the effects of cross-ownership.

³ Saving (1970) or Schmalensee (1977) include a more detailed review of other shortcomings of the *HHI*.

3. Concentration and cross-ownership in oligopoly

In industries with significant cross-ownership of shares the investors' incentives in deciding their firms' outputs may be substantially changed. Broadly speaking, cross-ownership means that an investor's profit is a combination of the profits earned in several competing firms. Consequently, the marginal profit earned by an investor from a firm's increased output includes not simply the marginal profit of that firm in isolation, but also the marginal impact on the profits of the competing firm. From the standpoint of the investor, therefore, the optimal output for each individual firm is less than in the standard Cournot-Nash model. A simple, if extreme, case which illustrates the problem is a duopoly with both firms owned entirely by the same investor: from the investor's viewpoint the optimal output for each is one-half of the monopoly output.

3.1. The Cournot model with cross-ownership

A formal treatment of the new equilibrium requires a restatement of the firm's objective function. Therefore, within the same Cournot framework, we now assume that there are M potential investors ($i=1, \dots, M$) and denote by β_{ij} investor i 's ownership share of firm j (where $\sum_i \beta_{ij} = 1$ for each firm j). Also denote investor i 's profit on its investment in all firms by $\pi^i = \sum_j \beta_{ij} \pi_j$. For the time being (we discuss this assumption further below), we also consider that it is possible to measure investor i 's degree of control of firm j by a non-negative parameter $\gamma_{ij} > 0$ where $\sum_i \gamma_{ij} = 1$ for each firm j , such that firm j chooses x_j to maximize the weighted profit of its owners, $\Pi_j = \sum_i \gamma_{ij} \pi^i$. This leads to

$$\max_{x_j} \sum_{i=1}^M \gamma_{ij} \pi^i = \max_{x_j} \sum_{i=1}^M \gamma_{ij} \sum_{k=1}^N \beta_{ik} \pi_k = \max_{x_j} \sum_{i=1}^M \gamma_{ij} \sum_{k=1}^N \beta_{ik} [p(X)x_k - c_k(x_k)], \quad (3.1)$$

and, assuming (for simplicity) that an owner's degree of control, γ_{ij} , is equal to her ownership stake, β_{ij} , the first order condition for an interior solution is (for $j=1, \dots, N$):

$$\frac{\partial \Pi_j}{\partial x_j} = \sum_{i=1}^M \gamma_{ij} \left\{ \beta_{ij} [p - c'_j(x_j)] + \sum_{k=1}^N \beta_{ik} p'(X)x_k \right\} = 0. \quad (3.2)$$

Comparing (3.2) with the first order condition (2.2) from the standard Cournot model, it is shown that cross-ownership substantially alters the initial equilibrium output, and therefore undermines the validity of the *HHI* as a proxy for the Lerner index as shown in (2.5).

Table 3.1. A numerical example of Cournot with and without cross-ownership

	Output	Mkt share	Price	Lerner	Elasticity	<i>HHI</i>	<i>HHI/Elast.</i>
Without cross-ownership ($b=0$)							
Firm 1	1	0.5	–	0.5	–	–	–
Firm 2	1	0.5	–	0.5	–	–	–
Industry	2	1	2	0.5	1	0.5	0.5
With cross-ownership ($b_{A2}=0.4$)							
Firm 1	0.69	0.38	–	0.54	–	–	–
Firm 2	1.15	0.62	–	0.54	–	–	–
Industry	1.84	1	2.15	0.54	1.17	0.53	0.46

Table 3.1 illustrates this idea for a simple numerical example with two firms (1 and 2) and two investors (A and B). Suppose that $p(X) = 4 - X$ and $c_1 = c_2 = 1$ and that firm 1 is fully controlled by investor A, who also has a non-controlling minority stake (of 40%) in firm 2. Thus, using the nomenclature above, $\beta_{A1} = \gamma_{A1} = 1$, $\beta_{A2} = 0.4$, $\gamma_{A2} = 0$ and $\gamma_{B2} = 1$. This numerical example simply shows how the *HHI*/elasticity ratio and the Lerner index diverge due to the presence of cross interests (the firms are identical in any other respect). Cross-ownership breaks the equality expressed in equation and distorts the antitrust policy implications of the Hirschman-Herfindahl index.

3.2. The generalized Hirschman-Herfindahl index

A number of authors have addressed the problem of cross-ownership and the provision of a right measure of concentration in this case. Maxwell *et al.* (1999) suggest a generalized Hirschman-Herfindahl index (*GHHI*) that takes into account the cross-ownership and successfully ties the observed market shares with the Lerner index measure of performance. Starting from the first order condition in equation (3.2), and multiplying through by X/X and $1/p$, we obtain

$$\sum_{i=1}^M \gamma_{ij} \left\{ \sum_{k=1}^N \beta_{ik} \left(\frac{p'X}{p} \right) \frac{x_k}{X} \right\} + \sum_{i=1}^M \gamma_{ij} \beta_{ij} \frac{p - c'_j(x_j)}{p} = 0. \quad (3.3)$$

After rearranging sums we have

$$L_j = \frac{p - c'_j(x_j)}{p} = \frac{1}{\mathbf{h}} \sum_{k=1}^N \frac{\sum_{i=1}^M \mathbf{g}_j \mathbf{b}_{ik}}{\sum_{i=1}^M \mathbf{g}_j \mathbf{b}_{ij}} s_k, \quad (3.4)$$

and multiplying both sides by s_j and summing over all j yields

$$L \equiv \sum_j s_j L_j = \sum_j s_j \frac{p - c'_j(x_j)}{p} = \frac{1}{\eta} \left\{ \sum_{k=1}^N \sum_{j=1}^N \frac{\sum_{i=1}^M \gamma_{ij} \beta_{ik}}{\sum_{i=1}^M \gamma_{ij} \beta_{ij}} s_k s_j \right\} \equiv \frac{1}{\eta} \text{GHHI}. \quad (3.5)$$

Finally, by separating out the terms for which $k=j$, the expression for the *GHHI* in brackets in (3.5) can be rewritten as

$$\text{GHHI} = \text{HHI} + \sum_{j=1}^N \sum_{k \neq j}^N \frac{\sum_{i=1}^M \gamma_{ij} \beta_{ik}}{\sum_{i=1}^M \gamma_{ij} \beta_{ij}} s_k s_j. \quad (3.6)$$

To carry out the calculations using actual data on market shares and ownership and control parameters, it helps to write expression (3.6) in matrix form. This gives

$$\text{GHHI} = \mathbf{s}' \Phi \mathbf{s}, \quad (3.7)$$

where $\mathbf{s} = (s_1, \dots, s_N)'$ is a transposed vector of market shares, and Φ is the matrix of cross-ownership coefficients,

$$\Phi = \begin{bmatrix} \phi_{11} & \cdots & \phi_{1N} \\ \vdots & \ddots & \vdots \\ \phi_{N1} & \cdots & \phi_{NN} \end{bmatrix}, \text{ defined by } \phi_{kj} = \frac{\sum_{i=1}^M \gamma_{ij} \beta_{ik}}{\sum_{i=1}^M \gamma_{ij} \beta_{ij}}.$$

Note that the *GHHI* – computed using any of these formulae – for the numerical example in Table 3.1 above is 0.625. Dividing the *GHHI* by the price elasticity of demand parameter yields 0.54, i.e., the *correct* industry-wide Lerner index. Therefore, the *GHHI* defined in (3.6) or (3.7) recovers the relationship between the concentration index and market power. This feature is essential in the antitrust policy uses of the Hirschman-Herfindahl indices and implies that the *GHHI* should replace the simple *HHI* calculations in industries where cross-ownership of shares plays a relevant role.

In addition, the *GHHI* also retains an easy economic interpretation. Whereas the *HHI* ranges from $1/N$ (for minimal concentration), to 1 (in the highest concentrated industries), the maximum value for *GHHI* – when market structure represents that of a single monopolist is also 1 – as can be checked from equation (3.6). In the case of minimal concentration (each firm having a market share of $1/N$), the *GHHI* is equal to

$$GHHI = \frac{1}{N} + \sum_{j=1}^N \sum_{k \neq j}^N \phi_{kj} s_k s_j,$$

where the second term is larger the higher the cross-ownership coefficient and becomes zero (moving back to the *HHI*) if cross-ownership is irrelevant. Note that it is not possible to define a general minimum value of *GHHI* to compare across different industries, since it will be always determined by the level of cross-ownership in each market.

4. The implementation of the *GHHI* in practice

Theoretically speaking, the *GHHI* is superior to the simple value of *HHI* in industries with relevant cross-ownership ties. Yet implementing the *GHHI* in practice is not problem-free and requires careful calculations. In particular, once that cross-ownership interests have been identified and proper market shares have been defined, the major issue becomes determining the weights that should be given to each shareholder in constructing the firms' objective functions, i.e., assigning the weights used in equation (3.6).

So far it has been assumed that investor i 's ownership share in firm j (namely, β_{ij}) and her corresponding degree of control (γ_{ij}) could be easily measured. Whereas the first parameter can be safely approximated by her number of dividend-earning shares in a corporation, the second one critically depends on the specific voting rights conferred to those shares. The starting assumption could be – as used in (3.2) above to simplify – that control rights are always directly proportional to each investor's ownership rights. This *one-share one-vote hypothesis* (that is, $\gamma_{ij} = \beta_{ij}$ for all i and j) can be viewed as a benchmark but in practice, corporate governance rules in most countries impose most complex control mechanisms within the firms.

4.1. The use of coalition formation indices for control measurement

Many recent contributions in the corporate governance literature increasingly define the investors' degree of control over a firm as their ability to influence a decision taken through a voting process in a company meeting (Levy, 1982). To measure this power, there exists a wide range of indices relying on game-theoretical approaches, that summarize the relative degree of control attained to a single shareholder or a group (or coalition) of these. Two of the most popular voting power indices are the Shapley-Shubik index and the Banzhaf index.

The Shapley-Shubik index (*SSI*) (often labeled *Shapley value*) is a widely used measure of a player's power in any voting game. Given the rules of voting and the

distribution of votes among the players, the *SSI* measures how often a player contributes to the creation of a winning coalition of votes. The measure of “how often” is based on a count of possible permutations among players and the marginal contribution of each player’s votes to the success of a coalition. The measure is therefore divorced from any underlying factors in particular situations that might generate natural coalitions arising out of shared interests.

The Shapley value has only recently been used in an analysis of shareholder control of corporations.⁴ It is typically calculated using the simplifying assumption that a majority of the common stock yields control of the company. However, it is relatively straightforward to generalize this condition to cases with distinct classes of stock, each with different voting rights, since they are identical to the many cases of differential voting rights analyzed extensively in other contexts (see for example Straffin, 1977).

There are other constraints placed on the firms’ governance rules that are not so easily folded into the *SSI* calculation. For example, certain corporate decisions may require different majorities. While a Shapley value can be easily calculated for the game with a simple majority or for the same game with a supra-majority (less than 50% to win a voting), a trickier question is how to calculate the value of a single game where some decisions are made on the basis of the simple majority and others are made with different majorities. This issue demands a detailed analysis of the corporate governance rules that apply to any specific sector or country, and in particular, a exhaustive examination of the rules regarding the rights of different classes of stock in the appointment of directors or the establishment of specific board committees, and the majority rules required for specific classes of decisions affecting the company’s operating activities.

The Shapley-Shubik index relies on the contribution made by the *pivotal* shareholder to winning coalitions. It is therefore biased towards large shareholders (which enter more frequently in winning coalitions) and does not always represent the wide variety of combinatorial possibilities that may possibly arise within a voting game. In some cases, for example when super-majority (over 50%) is requested, a minority shareholder can block key decisions and so its power control can be higher than expected. This problem is solved by the Banzhaf index, which modifies the *SSI* by attaching the same weight to the coalitions or blocks regardless of their size and then calculates a simpler probabilistic value.

The basic principle upon which Banzhaf index relies is that voting power is derived from your ability to change – or more precisely, your probability of changing – the outcome of the election with your vote. The Banzhaf index ignores coalitions that require more than simple majority to win decisions. It is based in principle on an absolute majority rule (a decision wins with strictly over 50% support). However, if the voting game requires different majorities, the index can be modified accordingly by simply changing the number of votes required to form a winning coalition.

Although the differences between Banzhaf and Shapley-Shubik indices are subtle, both are based on the same principle of control measurement through a critical voter. In this paper we will mainly use the Shapley-Shubik index for simplicity, although the rules for correcting majorities and defining winning coalitions will be derived from the Banzhaf

⁴ For example, Rydqvist (1988) uses the Shapley value to test hypotheses about the value of votes among Swedish companies with dual class shares. Zingales (1995) uses it to measure the benefits of control for Italian companies. Leech (1987, 1988) employs the Shapley value to calculate ownership concentration and control measures in US and British corporations.

index definition, taking additionally into account the specific corporate governance rules that apply to Spanish firms.⁵

4.2. Board membership as a control criterion: the Spanish rules

During the 1980s most European countries carried out major legal reforms in their corporate governance rules in preparation for the Single Market of 1992.⁶ In Spain these changes started in 1988 with the *Securities Markets Act*, which established an independent regulatory authority, the CNMV (*Comisión Nacional del Mercado de Valores*) and introduced new mechanisms regarding the disclosure of ownership information for listed firms as well as several qualifications on the direct and indirect stakes that any given investor could hold on a Spanish company.

In particular, since 1988 the Spanish law requires that any relevant change in ownership must be reported to the supervising authorities and targeted company within seven business days. A “relevant change” occurs whenever a shareholder’s stake increases above 5% or any multiple of 5%, or decreases below 5% or any multiple of 5% of the capital stock of a company. In the case of a foreign investor, the report must be also filed with the Ministry of Finance, and if the operation involves any member of the company’s board of directors the report the transaction must be reported to the company and the CNMV, regardless its size. In addition, any person or group that – either directly or indirectly – controls 10% or more of the outstanding shares of a listed company must give notice to that company. Failure to do so may imply losing the corresponding voting rights.

A second major change following the 1980s reforms was the translation to the Spanish legal system of several EC directives on clarifying control rights. The transparency directive of 1988 emphasized the public knowledge of large shareholdings, and the exact quantifying of the voting rights that each person or firm can exert. It made a distinction between *direct stakes* (or direct representation) and *voting blocks* (when intermediate companies or “business groups” are designed as a bridge to exert large accumulated voting powers). Both types of participation are widely used in Spain.

In addition, Spanish listed companies also use standard anti-takeover devices such as voting caps, supermajority requirements for some decisions, or statutory rules that make more difficult the access to the board of directors and indirectly attributes more control capacity to the decisions taken by it. The relevance of the board of directors becomes even more important in inter-sectoral comparisons across Spanish industries because it is relatively frequent that many large companies share a relatively small group of relevant people that participate in the board of directors of two or more companies. The number of directors that any particular group of investors can name within a company it is not always a direct function of the ownership degree, since it also depends on the voting blocks or internal pacts achieved among the investors and the atomization of the remaining shareholders.

In general, in order to gain the right to appoint or remove board members, it is often unnecessary to own more than 50% of shares. Alternative thresholds, such as 25% of the shares or even lower figures, depending on each firm’s statutes, could be sufficient criteria in most cases. Therefore, the relative number of board members appointed by each group

⁵ For a recent comparison of Banzhaf and Shapley-Shubik indices results in the analysis of the ownership structure of Spanish firms see Leech and Manjón (2001).

⁶ This section draws on the splendid survey by Crespí-Cladera and García-Cestona (1998).

of shareholders could possibly become a third alternative way to define control, together with the *one-share one-vote* hypothesis and the use of coalition indices as described above.⁷ However, in practice one important caveat applies. The Spanish law does not obligates to reveal the existence of internal contractual arrangements among shareholders for voting blocks, and to the extent that these kind of agreements are not publicly reported, such a criterion will be always based on simplifying assumptions. The following section tries to translate all these theoretical features into a workable example.

5. Using *GHHI* in the Spanish electricity sector

Spain's electricity industry has gone through a profound liberalization process during the last three decades. From a heavily government controlled but fragmented framework, it has moved to a larger degree of concentration under complete private ownership. By mid-2001 the sector was composed by four large, publicly quoted, corporations (*Endesa*, *Iberdrola*, *Unión Fenosa* and *Hidrocantábrico*), owned by a diverse group of shareholders, some of them with significant cross-ownership ties in the companies. Therefore, the sector seems a suitable candidate for our *GHHI* example.⁸

5.1. The liberalization of the Spanish electricity sector

The modern development of the electricity sector in Spain can be traced back to the industrial growth that started during the 1950s. The government's low price and expanding capacity policies favored the production of relatively abundant and cheap energy from hydroelectric and fuel origin which played a vital role in the country's expansion. Alas, the 1973 crisis hit the Spanish economy very hardly and excess capacity and financial distress became a huge problem. The situation prompted increases in tariffs, restrictions to competition and larger horizontal concentration processes.

The 1986 *Electric Protocols* adopted the first steps to redraw the rules in the market, but it was not until the *Electric System Act* of December 1994 when the liberalization process truly started. The law defined electricity as a public service, but assigned to private operators the actual operation of the system. It only reserved to the government the overall planning capacity and the general regulation of the market. Electricity generation and its distribution to final user would be liberalized, and could be carried out freely by private companies. Energy transportation from origin to final consumers through the national network of electric lines would use the infrastructure of *Red Eléctrica de España*, a natural monopoly company with government and private participation. In addition, it was agreed that tariffs would be progressively reduced and consumers would have greater possibilities of choice among electricity providers, which would compete with each other and with new entrants.

⁷ It is immediate to note that the Shapley and /or Banzhaf indices can be also applied to study coalition formation within the board of directors, instead of only in the shareholders' general assembly, as implicitly assumed so far (see Arthur, 2001). The choice should depend on the available information and the extent to which any particular decision is taken or approved either by the board or the assembly (Jensen and Warner, 1988).

⁸ This sector has already attracted previous research on market power (see García-Díaz and Marín, 1998, or Atienza *et al.*, 2001, for example), but none of them from the cross-ownership perspective. These studies also criticize the use of *HHI*-type indexes on this industry on the grounds that there is not Cournot competition in the electricity sector. Despite this being true, the *HHI* is nonetheless still used as a general tool by many competition agencies. In these sense, our paper should be interpreted as a criticism to this generalized use, not as a representation of the competition in the actual electricity industry.

The law also created an electricity regulator, the CNSE (*Comisión Nacional del Sistema Eléctrico*) as the body responsible for ensuring effective competition in the electricity system and that the system works in an objective and transparent way for the benefit of consumers and all the agents operating in it. The agency had wide-ranging regulatory and executive powers, covering areas such as the settlement of electricity transmission and distribution costs, dispute settlement, and authorization of participation by utilities in regulated activities. Later in April 2000, the CNSE became the CNE (*Comisión Nacional de la Energía*), the energy watchdog, with ampler but more diluted supervision powers.⁹

The 1997 *Electricity Act* drew a specific calendar for the liberalization to take place in the industry. It was initially established a 10-year transition period for firms to adjust the competition framework. On January 1st 1998, the Spanish electricity market was opened up to competition, such that all consumers with an annual consumption of more than 15 GWh were allowed to choose their supplier. However, since competition was initially slow to develop, the CNSE proposed an extension of supplier choice to consumers with annual consumption of more than 1 GWh (who would not have been allowed supplier choice until 2004 under the original plan). The government subsequently opened negotiations with the utilities to speed up the timetable for market liberalization and, eventually, reached an agreement in return for concessions on stranded costs (aptly named “competition transition costs” or CTCs).

Spanish utilities had argued for some time that greater competition would mean that a higher level of stranded costs would arise from investment made in power plants and infrastructure before liberalization was approved. The government finally accepted this argument and allowed the conversion into securities of approximately €6 billion of CTCs. In return for this level of cost recovery, the utilities agreed to accept greater tariff reductions. The timetable for liberalization was also accelerated. According to the original schedule, the threshold for consumers choosing their supplier and negotiating their own electricity price was to be lowered to include those who use more than 9 GWh in 2000 (affecting about 1,000 firms in all). Under the terms of the new agreement, from January 1st 1999, the limit was reduced to 5 GWh (2,000 consumers); from mid-1999; it was reduced to 1 GWh, which resulted in the liberalization of about 44% of total electricity consumption. Domestic consumers will be able to choose their supplier from 2002.

Under these legal and economic framework, the current structure of the Spanish electricity sector has been dominated by four large corporations: *Endesa*, *Iberdrola*, *Unión Fenosa* and *Hidrocantábrico*, which have adapted to the liberalization process. In 1995 these companies produced slightly over 150,000 GWh of electricity.¹⁰ In 1999, total production was over 208,000 GWh and less than 5% of total consumption was imported. The generation market shares were asymmetrically distributed: *Endesa* (49.03%), *Iberdrola* (32.3%), *Unión Fenosa* (13.12%) and *Hidrocantábrico* (5.52%), and cross-ownership interest – particularly from banking groups – were relevant across some firms. However, prior to applying the *GHHI* to this sector, it is useful to review first the events behind the failed merge between *Endesa* and *Iberdrola* in 2000.

⁹ The main difference between CNSE and CNE appears to be that the government will exert much tighter control over what CNE than it did over CNSE. For example, article 51 of the government decree on CNE directly states that “the Ministry will exercise control of the effectiveness of the Commission’s activity”.

¹⁰ Market shares in transmission were *Endesa* (41.02%), *Iberdrola* (39.68%), *Unión Fenosa* (15.19%) and *Hidrocantábrico* (4.11%), whereas in distribution, 44.30%; 41.02%; 11.45% and 3.23%, respectively.

5.2. The failed merge between *Endesa* and *Iberdrola*.

One of the most interesting developments in the Spanish electricity industry in recent years has been the failed merge attempt between the two largest companies, *Endesa* and *Iberdrola*, whose uncertain outcome and potentially relevant implications on competition draw considerable attention both within and outside Spain.

The process dates back to the beginning of 1999, when the Ministry of Industry gave permission to new operators, US *Enron* and SKS, from Norway, to enter the Spanish energy markets. As a reaction to these movements, and seeking a strategic positioning to face new entries, in November 1999 *Iberdrola* announced a merger plan with *Repsol*, a Spanish petrochemical multinational with important ties in Latin America, and *Gas Natural*, the monopolistic operator of gas in the domestic market. Although the plan was rolled back one month later, *Endesa*, started to think that her own merger with *Iberdrola* could eventually prevent that strong competitors (such as *Repsol* or any foreign firm) could take relevant stakes in the Spanish electricity sector or in other related energy market.

Although the existing protocols – signed by the government and the operators – required a minimum of four competitors for the electricity market, *Endesa* argued that the real competition contest was not inside the country, but at the European level, where a larger size was needed to compete against rivals. In addition, *Veba* and *Viag*, and *RWE* and *Veag* had been allowed to merge in Germany, whereas in France, *Electricité de France* (EDF) still enjoyed a comfortable monopoly in the domestic market.

A relevant issue in the process was the problem of cross-ownership. All four large electricity operators included the most important banking groups – *Caja Madrid*, BBVA, BSCH and *La Caixa* – among their shareholders, so that conflict of interests could emerge. Additionally, the private agreements between *Iberdrola*, *Repsol* and *Gas Natural*, could be also troublesome, since competition in the electricity market was highly affected by competition in the gas market. However, all these issues were quickly settled during the negotiation of the fusion agreement by representatives of the firms, which agreed upon the idea that their union was a natural reaction to the government's restrictions about the growth of their two firms, the uncertainty of the compensation of the stranded costs (contested by the European Commission, although finally approved) and the concentration trends hinted by European rivals.

Despite the opposing votes of *La Caixa* and BBVA representatives, the firms' boards of directors approved their merger agreement during the first quarter of 2000. The resulting company – with almost 20 million customers – would be the world's fifth electricity utility in cash-flow, with a total market value above €37 billion and assets over €68 billion. The CNE also gave its acquaintance in the second semester of 2000, but imposed certain conditions. It established limits on the overall market shares that *Endesa-Iberdrola* would enjoy in the Spanish domestic market, setting a maximum of 45% in generation and 41% in distribution. It also ruled that the transmission networks should be independently managed during 3 years and that a relevant number of assets should be sold out, although without specifying the mechanism.¹¹

Such an important merger process fell also under the jurisdiction of the Spanish competition agency, the *Tribunal de Defensa de la Competencia* (TDC). The 1986 *Competition Act* stated that TDC approval was required to give permission to the fusion to

¹¹ The CNE approval was a formal requirement, since it could be accepted or rejected by the government. Similarly, the competition agency report could be also rejected by the Ministry of Economy.

proceed, although any final decision was left in the hands of the government. In January 2001, after evaluating the level of competition that would exist in the sector had the merger been allowed, the TDC released its report. Authorization was given conditional to meeting several very restrictive conditions regarding disinvestments. The resulting company had to sell enough assets before the merger in order to get only a 35% market share in electricity generation, a 41% in transmission and a maximum of 48% in distribution. The TDC recommended auctions as the best mechanism for the sales, but left open the possibility other formulae upon agreement with the buyer.

A few weeks later, the government announced its final decision over the *Endesa-Iberdrola* merger. It followed the advices of the CNE and TDC on allowing the fusion *only* if very restrictive conditions were met. The national interest arguments used by the companies to defend their plan were discarded in favor of the competition argument. It was thought that the level of concentration after the merge would have been excessive and tough disinvestment requisites were demanded. In addition, the government hinted that the merge would convey an unfavorable revision of the CTCs agreement. As a result, the companies rolled back their plan in February 2001.

5.3. The level of concentration in the Spanish electricity sector

In this final section we use both the standard *HHI* and our proposed *GHHI* to measure the exact level of concentration in the Spanish electricity sector. Following the events just described above we divide our analysis into three different stages or scenarios. As an initial benchmark, *Scenario 0* corresponds to the existing situation in mid-1999, just before the announcement of merger by *Repsol*, *Iberdrola* and *Gas Natural*. We consider an average of the six months before this announcement because during this period there were several capital movements seeking good market positions.¹² Secondly, *Scenario 1* hypothesizes what would have happened if the merger had succeeded. Here we assume that final market shares would be the simple addition of the previous market shares of *Endesa* and *Iberdrola*, and that their shareholders and board compositions would reflect the agreement reached and publicized by the companies. Of course this is not a real scenario. Our purpose is simply to provide a ‘*worst-possible situation*’ benchmark in order to test the power of our *GHHI*. Finally, *Scenario 2* studies the level of concentration in the industry if the merger had proceeded but in compliance with the restrictions imposed by the Spanish competition agency. In all cases we compare the *HHI* with the *GHHI*, although in the later we made the suitable assumptions for control.

Scenario 0: the concentration level in 1999

Consider first the situation in 1999. Table 5.1 shows market shares (defined in output terms) for the four major companies in this industry. We have excluded imports and the output of smaller operators since their relative importance at this date was very small. We distinguish between three different electricity businesses – generation, transmission and distribution – and our data show that in all three cases *Endesa* and *Iberdrola* together account for more than 80% of the markets.¹³

¹² In addition, *Hidrocantábrico* also suffered from some movements in its shareholder distribution, following takeover attempts by foreign firms (TXU and EDP).

¹³ Electricity transmission in Spain is mainly carried out through a different firm, *Red Eléctrica Española* (REE), which is participated by the electricity generating firms. Therefore, market shares in transmission have been calculated taking into account these participations.

The corresponding Hirschman-Herfindahl indices are relatively medium size, once taken into account that the minimum value is $1/N = 0.25$ and the maximum equal to 1. The market structure reveals itself as that of an oligopoly with two dominant firms.¹⁴

Table 5.1. Market shares and Hirschman-Herfindahl index in 1999

	Generation	Transmission	Distribution
Endesa	0.4903	0.4102	0.4430
Iberdrola	0.3233	0.3918	0.4102
Unión Fenosa	0.1312	0.1519	0.1145
Hidrocantábrico	0.0552	0.0451	0.0323
HHI	0.3682	0.3468	0.3787

Source: Average of CNE reports in 1999. Foreign operators excluded.

To go from the simple *HHI* analysis to the use of *GHHI* further details about the ownership and control mechanisms within these firms are needed. All of them are publicly quoted companies in the Spanish stock market and, therefore, their internal composition and annual reports are openly available through the financial regulator, the CNMV. However, internal voting pacts, indirect stakes (of one shareholder over another shareholder) and the exact affiliation of some members in the board of directors is not always clear, so that some assumptions will have to be made. Table 5.2 shows the known groups of shareholders with significant interests in the capital of the studied firms in 1999.

At first glance, one of the most salient features from Table 5.2 is that the level of cross-participation is relatively limited: only three groups EDP – a Portuguese electricity company – and the largest banks in Spain – BSCH and BBVA – have relevant stakes in more than one firm. Competition laws in many countries restrict the level of cross-ownership in most industries, so that distortions are small. It is difficult to find any particular sector in any country that, under normal circumstances exhibits very large figures for cross interests. In addition, in this case this feature should be viewed as a positive one for our research agenda, since if we show that there are significant differences between *HHI* and *GHHI*, then our hypothesis that the later is superior to the former is reinforced.

With regard to the distribution of different groups of shareholders on these companies, in the case of *Hidrocantábrico*, *Ferroatlántica* is a Spanish group that owns electric plants with 177 MW of electric power. It is associated with *EnBW*, a German company participated by its government and the French EDF. EDP (*Electricidade de Portugal*) is also closely associated to *Cajastur*, a medium-size financial institution from the North of Spain. In *Unión Fenosa*, *Banco Pastor* and *Caixa Galicia* are also medium size banks, whereas BSCH – with a 10% stake – is the largest minority shareholder. BBVA plays a similar role in *Iberdrola*, where it also has an indirect participation through BBK (a savings bank). A large proportion of capital is floated in atomistic participations in the stock market, or is owned by investment funds with speculative, not control, interests.

¹⁴ Although we do not analyze firms' performance, the progressive price liberalization since 1996 does not preclude the existence of a Lerner index-market concentration relationship as described earlier in this work. See also footnote 8, on the representativeness of Herfindahl index in this industry.

Something similar happens in *Endesa*, where the relevant shareholders (those with voting rights in the board of directors) are *Caja Madrid*, *La Caixa*, BSCH and BBVA. The Spanish government retains a 3% through the SEPI, as a residual from former times.¹⁵

Table 5.2. Shareholders in Spain's electricity sector in 1999

	Endesa	Iberdrola	Unión Fenosa	Hidrocarbónico
BSCH	0.030	–	0.100	–
La Caixa	0.049	–	–	–
Caja Madrid	0.049	–	–	–
BBVA	0.030	0.095	–	–
BBK	–	0.050	–	–
EDP (Portugal)	–	0.040	–	0.192
Banco Pastor	–	–	0.050	–
Caixa Galicia	–	–	0.050	–
Ferroatlántica-BW	–	–	–	0.596
Cajastur	–	–	–	0.100
Caser	–	–	–	0.050
Foreign institutions	–	0.335	–	–
Stock market (*)	0.613	0.340	0.726	0.062
Investment funds (*)	0.200	0.140	0.074	–
SEPI (**)	0.029	–	–	–

Source: Own elaboration from CNMV and companies' reports. Cross-participations appear highlighted.

(*) The capital floated in the stock market and the shares owned by investment funds belong to different shareholders, and do not constitute an example of cross-ownership. (**) SEPI belongs to the Spanish government.

As described in Section 3 above our generalized Hirschman-Herfindahl index (*GHHI*) critically depends on the exact definition of degree of “ownership” and “control” exerted by the stakeholders. Whereas the former can be easily identified with the percentage of shares with profit rights held by any particular shareholder (see Table 5.2), the latter admits at least three alternative definitions: control can be defined by the degree of ownership, by the capacity to form winning coalitions in the company's voting games or by the relative number of directors appointed by each group of investors in the board of directors. Let us examine each of these alternatives by turn recalling that β will represent the ownership coefficient and γ the control coefficient.

¹⁵ The Spanish government also enjoys *golden share* mechanisms in privatized electric utilities to block decisions “against the national interest”.

1. The one-share one-vote hypothesis

Here we implicitly identify profit rights with voting rights; although this is possibly a too simplistic rule – mainly calculated for comparative purposes – it provides a useful starting value. Recall equation (3.7) defining the matrix form of the $GHHI = \mathbf{s}'\Phi \mathbf{s}$, where \mathbf{s} was a vector of market shares and Φ the matrix of control-ownership coefficients (ϕ_{kj}). Note that under this working hypothesis $\gamma_{ij}=\beta_{ij}$ for all i and j and these coefficients simplify into:

$$\phi_{kj} = \frac{\sum_{i=1}^M \beta_{ij} \beta_{ik}}{\sum_{i=1}^M \beta_{ij}^2},$$

where the β s are the values represented in Table 5.2.

In this case, with four major companies, Φ is a 4×4 matrix given by:

$$\Phi_1 = \begin{pmatrix} 1 & 0.0101 & 0.0054 & 0 \\ 0.0067 & 1 & 0 & 0.0188 \\ 0.0070 & 0 & 1 & 0 \\ 0 & 0.0272 & 0 & 1 \end{pmatrix},$$

where the order represented in rows and columns corresponds to *Endesa*, *Iberdrola*, *Unión Fenosa* and *Hidrocarbónico*, respectively. Note that the ones in the main diagonal state the degree of cross-ownership of one company over herself and the zeros reflect the cases of no cross-interests. Interestingly, note also that in case of null cross-interests among all the shareholders, Φ would simply be a unit matrix, and $GHHI$ in expression (3.7) would collapse into HHI , as expected.

However, in the Spanish electricity sector under *Scenario 0* there were some cross-interests among the companies, at least to the extent shown by Table 5.2. Thus, using the market shares defined by Table 5.1 and this Φ -matrix, the resulting $GHHI$ values would be **0.3694** for generation, **0.3512** for transmission, and **0.3830** for distribution to final user. When compared with the HHI figures in Table 5.1, it is immediate to see that $GHHI > HHI$ in all three markets, reflecting the fact that the Hirschman-Herfindahl index undervalues market power by no considering the effects of cross-ownership. The relative difference within each ($GHHI$, HHI) pair is very small (0.3%, 1.2% and 1.1%, respectively), but this feature changes with alternative definitions of the degree of control.

2. The relative number of directors hypothesis

We will now consider the alternative hypothesis that the degree of control of any particular group of investors over a company is defined by the relative number of directors appointed by that group in the board. In Spain, this information is usually available through the CNMV, and the reports and press notes filed by the companies, but sometimes it is very difficult to know the exact affiliation of some board members. With this caveat in mind, we have constructed Table 5.3, which provides a tentative approach to the internal composition of the boards of the Spanish electricity companies at the beginning of 1999.

Table 5.3. Board members in Spain’s electricity sector in 1999

	Endesa	Iberdrola	Unión Fenosa	Hidrocantábrico
Caja Madrid	1	–	–	–
La Caixa	1	–	–	–
BBVA	1	5	–	–
Neguri family	–	6	–	–
BSCH	1	–	2	–
Caixa Galicia	–	–	1	–
BBK	–	1	–	–
Banco Pastor	–	–	1	–
Cajastur	–	–	–	1
Others	11	10	18	15
Total board members	15	22	22	16

Source: Own elaboration from CNMV and companies’ reports. Cross-participations appear highlighted.

The γ -coefficients for all major shareholders can be calculated from the relative powers extracted from Table 5.3. For example if five directors in *Iberdrola*, whose board is composed of 22 members in total, are appointed by BBVA, then γ_{BBVA} should be 5/22, or 0.2273. In some cases, there are some groups of individual investors that form known voting blocks. This is the case of the Neguri family in *Iberdrola*, a group of shareholders with familiar ties that usually act together in collective decisions within the company. There are other special cases, such as EDP, which has no directly appointed board members neither in *Iberdrola* or *Hidrocantábrico* in spite of its significant ownership share. Finally, we have included within *Others* “independent” board members or those with unknown (or multiple) affiliations.

Not surprisingly, the corresponding Φ -matrix for this case only reflects the cross-interests of BBVA and BSCH in *Endesa*, *Iberdrola* and *Unión Fenosa*:

$$\Phi_2 = \begin{pmatrix} 1 & 0.1369 & 0.1971 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}.$$

With these coefficients, the corresponding *GHHI* values for generation, transmission and distribution in the Spanish electricity sector in 1999 would be **0.4000**, **0.3808** and **0.4135**, respectively. Again, compared with the *HHI* values in Table 5.1, the *GHHI* are higher and this time the relative differences are also large (8.6%, 9.8% and 9.2%). This suggests that the relative number of directors hypothesis for the definition of the degree of internal control attaches more importance to cross-interests than the simple one-share one-vote mechanism.

3. The coalition formation hypothesis

A final – and more complex – way to define control consists in calculating power indices through the capacity of relevant shareholders to form coalitions in voting games within the shareholders’ general assembly or within the board of directors. Any computation of these

indices requires a detailed knowledge of the firms' decision mechanisms. According to their statutes, some decisions must be finally made by the assembly (for example, merger decisions or the approval of accounts) whereas other (mostly operative) decisions are routinely taken by the board. For illustrative purposes, we preferred this second possibility and calculated the γ as the Shapley-Shubik indices for winning coalitions in the board of directors. Although some decisions may require a different percentage, we defined a winning coalition as having 51% of the votes.¹⁶

Under this assumption, the γ coefficient for *Iberdrola* would be 0.0209 (BBVA) or 0.0146 (BBK) for example, and similarly for the others. After calculating the ϕ_{kj} coefficients, the corresponding Φ -matrix for this case (which maintains the same structure that Φ_2) was:

$$\Phi_3 = \begin{pmatrix} 1 & 0.0492 & 0.1241 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}.$$

The resulting *GHHI* for the generation market was **0.3809**, **0.3622** for transmission, and **0.3939** for distribution to final user. In this case the relative increase of *GHHI* with respect to *HHI* is lower (3.4%, 4.4% and 4.0%, respectively) than under the relative number of directors hypothesis. This comes from the fact that the definition of control using Shapley values (coalitions) is less strict than using relative votes in the board. With Shapley (and Banzhaf) indices each shareholder's degree of control is reduced (as showed in Φ_3) by its dependence on other shareholders.

Scenario 1: the *GHHI* after a successful merger by Endesa-Iberdrola

The information provided by our *GHHI* in *Scenario 0* already improves the simpler analysis of the same industry using *HHI*. We now study – as a “worst case scenario” – the level of concentration in the Spanish electricity market had the merger attempt between *Endesa* and *Iberdrola* been successful. First consider again Table 5.1. A successful merger would have implied market shares above 80% for the resulting company in generation, transmission and distribution. By applying *HHI* to the sum of the market shares of *Endesa* and *Iberdrola* it is immediate to obtain a clear view of this substantial increase in market concentration: the *HHIs* would be **0.6822**, **0.6683** and **0.7421**, respectively.

In order to apply the *GHHI* we need to know how internal power would have been distributed in the merged company. Fortunately, the firms publicized their agreements, which included – among others – the following features (Atienza *et al.*, 2001):

- a) There would be an exchange of shares between *Endesa* and *Iberdrola* in a 1:1.27 proportion. Each *Iberdrola* share would be valued at €6.86. The new firm would issue 705.5 millions of shares at €1.2, with a total capital of €846.67 million
- b) There would be a disinvestment process in assets of the two merged firms to reduce their excess capacity and – in compliance with the electric protocols – allow the entry of new firms in the industry.

¹⁶ We tested different majorities (25%, 30%, 40% and 75%) to study the sensibility and stability of our results. In general – except in the cases of supermajorities of 75% – the results did not change. Supermajority requirements, however are rare in usual corporate decisions.

- c) The shareholder composition of the resulting company would be the following: BBVA (4.5%), *La Caixa* (4%), *Caja Madrid* (4%), SEPI (2.3%), BBK (2%), EDP (0.8%), BSCH (1.5%), other financial institutions (18%), other foreign institutions (2%), individuals (8.9%) and several US investment funds (17%). The remaining capital would be floated in the stock market.
- d) The board of directors of the company would be composed by 30 members (18 from *Endesa* and 12 from *Iberdrola*, in proportion to the ownership coefficients).

Note that a major source of uncertainty derived from this agreement is the role to be played by the new entrants. The merging companies relied on their disinvestments as a strategic device that intended to protect them (unsuccessfully, as we know) from anti-competitive accusations from the CNE or the TDC. However, since it is very difficult to evaluate the impact on concentration of one or more firms that were not in place yet, we have not included these “potential” competitors in the *GHHI* analysis at the moment and analyze this scenario with only three firms: *Endesa-Iberdrola* (merged), *Unión Fenosa* and *Hidrocarbónico*.

1. The one-share one-vote hypothesis

Under this simplifying assumption, the 3×3 Φ -matrix would be

$$\Phi_1 = \begin{pmatrix} 1 & 0.0027 & 0.0037 \\ 0.0075 & 1 & 0 \\ 0.0077 & 0 & 1 \end{pmatrix},$$

and the corresponding *GHHI*: **0.6838**, for generation, **0.6700** in transmission and **0.7432** in distribution. Observe that these figures are only slightly larger (0.2%, on average) than the corresponding *HHIs* calculated above. The same pattern of *Scenario 0* is repeated: the one-share one-vote hypothesis is not discriminating enough to study cross-ownership issues, but *HHI* undervalues the effect of concentration.

2. The relative number of directors hypothesis

The fusion agreement between *Endesa* and *Iberdrola* redistributed the members of the board of directors as described above. Modifying accordingly Table 5.3 (and under the *ceteris paribus* assumption), the new Φ -matrix would be:

$$\Phi_2 = \begin{pmatrix} 1 & 0.0985 & 0 \\ 1.0050 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

The resulting values of the *GHHI* would be now **0.8000**, **0.8027** and **0.8500** respectively for generation, transmission and distribution. All three values are much larger than their corresponding *HHIs*, overshooting them by 17.2%, 20.1% and 14.5%.

3. The coalition formation hypothesis

Under similar assumptions as above, the final way of defining control through voting power indices can be extended to *Scenario 1*. In this case, calculating the Shapley-Shubik index for winning coalitions of 51% we get a Φ -matrix:

$$\Phi_3 = \begin{pmatrix} 1 & 0.0619 & 0 \\ 0.9790 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

and the corresponding GHHI would be **0.7933**, for generation, **0.7951** in transmission and **0.8437** in distribution to final user. These values are lower than the figures in the relative number of director hypothesis, supporting the idea – stated in *Scenario 0* – that the measurement of control through coalition indices implies a less extreme definition of such control. The relative increment has been greater for transmission service.

It is quite interesting to note that the qualitative results of using both *HHI* and *GHHI* are similar: they detect increases in concentration fairly well. However, *GHHI* emphasizes the role of cross-ownership, increasing the concentration index more substantially. When approval of mergers and other decisions by the competition agencies depend of relative increases in these indices (as the FDC in the US; see footnote 2 above) quantitative differences can make an impact.

Scenario2: the GHHI and the TDC restrictions

After the previous analysis in *Scenarios 0* and *1* only a final discussion is left. What would have been the real impact on concentration of the disinvestment restrictions imposed by the Spanish TDC to the *Endesa-Iberdrola* merger? As described above, the TDC report in January 2001 approved the fusion if, and only if, the resulting company significantly reduced its capacity by auctioning it out to other competitors (it requires at least three new operators in the market).

It is difficult to foresee the outcome of these auctions, but we can provide some figures using the limits stated by the TDC to the merged company: 35%, 41% and 48% for generation, transmission and distribution to final user, respectively. These limits can be translated into Table 5.1, to recalculate all market shares under the assumption that none of the existing companies would change its share and that all the capacity reduction would be bought (in equal parts) by three new firms (none of which would have cross-ownership interests with actual shareholders in the market). Under these simplifying assumptions, for example, *Endesa-Iberdrola* would have 35% of generation, *Unión Fenosa* 13.12% and *Hidrocantábrico* 5.52%. The remaining 46.36% would be equally distributed among three (unnamed) firms (15.45% each one) and similarly for transmission and distribution. The corresponding *HHIs* would then be: 0.2144, 0.2447 and 0.2910, respectively.

In the other hand, to calculate the *GHHI* in this scenario we will maintain the internal power arrangements agreed upon by the companies, since the TDC resolution did not change them. The resulting Φ -matrices are the same than under *Scenario 1*, and therefore the corresponding *GHHI* values are the following:

1. The one-share one-vote hypothesis

- Generation. *GHHI* = 0.21488
- Transmission. *GHHI* = 0.2455
- Distribution. *GHHI* = 0.2917

2. The relative number of directors hypothesis

- Generation. *GHHI* = 0.2650

- Transmission. $GHHI = 0.3134$
- Distribution. $GHHI = 0.3516$

3. The coalition formation hypothesis

- Generation. $GHHI = 0.2621$
- Transmission. $GHHI = 0.3095$
- Distribution. $GHHI = 0.3481$

It is interesting to note that the final level of concentration after a successful merger is critically reduced, when compared to *Scenario 1*, by the disinvestment restrictions imposed by the TDC. However, $GHHI$ is still useful to detect the potential distortions associated to cross-ownership. In fact, as long as shareholders retain cross-participations in different firms within the same sector, $GHHI$ is superior to HHI regarding concentration measurement.

5.4. A quick summary of results

Table 5.4 provides a final summary and comparison of the calculations performed in this section. It summarizes the values of the HHI and the $GHHI$ calculated under different scenarios and for three different electricity markets: generation, transmission and distribution to final user. A number of significant differences emerge: note, for example, that in all cases the HHI always underscores the $GHHI$. By construction, this is simply reflecting the fact that Hirschman-Herfindahl index does not take into account the anti-competitive effects of cross-ownership, whereas our generalized $GHHI$ effectively does.

Table 5.4. A summary comparison between HHI and $GHHI$

	Generation	Transmission	Distribution
Scenario 0			
HHI	0.3682	0.3468	0.3787
GHHI (one share-one vote)	0.3694	0.3511	0.3829
GHHI (number of directors)	0.4000	0.3808	0.4135
GHHI (winning coalitions)	0.3809	0.3622	0.3939
Scenario 1			
HHI	0.6822	0.6683	0.7421
GHHI (one share-one vote)	0.6838	0.6700	0.7432
GHHI (number of directors)	0.8000	0.8027	0.8500
GHHI (winning coalitions)	0.7933	0.7951	0.8437
Scenario 2			
HHI	0.2143	0.2446	0.2910
GHHI (one share-one vote)	0.2148	0.2455	0.2917
GHHI (number of directors)	0.2650	0.3134	0.3516
GHHI (winning coalitions)	0.2621	0.3095	0.3481

Secondly, the exact value of the *GHHI* depends on the definition of the control parameter (γ). The extreme (lowest and highest) figures are always given by the one-share one-vote and the relative number of directors hypothesis, whereas the use of coalition formation indices provides an intermediate value.

We have also considered differences among scenarios. *Scenario 0* represents the benchmark case (the situation in 1999). *Scenario 1* is a “worst possible case”, with the highest concentration resulting from a successful *Endesa-Iberdrola* merger without restrictions. Scenario 2 allows us to compute the level of concentration that would have attained the market in case the companies had accepted the restrictions imposed by the competition agency.

Finally, there are some subtle differences across electricity markets since they all exhibit distinct concentration levels that arise from their own technological conditions. In our study, however, we have implicitly considered that generation, transmission and distribution were independent markets. A much deeper approach would have required to include in *GHHI* the relationships among them. This analysis, jointly with the effects of electricity on related markets (natural gas, petroleum) was beyond the scope of this paper, but it is considered an immediate line for future research.

6. Conclusions

The aim of this paper has been twofold. Firstly, we have showed that when the firms within a market are characterized by significant cross-ownership relationships among their stakeholders, the widely-used link between the Lerner index (i.e., a proxy for market power or firm’s performance) and the Hirschman-Herfindahl index (i.e., a measure of concentration, or the industry’s market structure) is broken. To overcome this problem – that might well jeopardize the foundations of antitrust analysis – we propose to replace the Hirschman-Herfindahl index (*HHI*) by a generalized version of it, the *GHHI*, initially developed by Maxwell *et al.* (1999). This generalized Hirschman-Herfindahl index explicitly incorporates the effects of cross-ownership on the standard Cournot model the *HHI*-Lerner linkage is based upon, allowing to recover it once the suitable ownership and control parameters are taken into consideration.

As a second feature of this paper, we have tried to develop an implementable version of the *GHHI* and illustrate its usefulness within a practical case. As an example, we have chosen the Spanish electricity sector, which is characterized by relatively high cross-ownership interests and several merger attempts – both successful and failed ones – in recent years. Our version of the *GHHI* critically depends on the exact definition of degree of “ownership” and “control” attributed to the stakeholders. Whereas the former can be easily identified with the percentage of shares held by any particular shareholder, the latter admits at least three alternative definitions: control can be defined by the degree of ownership (probably, an excessively poor assumption), by the capacity to form winning coalitions in the company’s voting games (represented through power indices derived from the Shapley value) or by the relative number of directors appointed by each group of investors in the board of directors.

We have tested all these three definitions to measure the concentration level in the Spanish electricity sector. Furthermore, we have applied *GHHI* instead of *HHI* to evaluate the failed merger attempt by the two largest companies, *Endesa* and *Iberdrola*, which was blocked by the government disinvestment conditions imposed over such operation. Our results show significant differences (ranging between 5% and 20%, depending on the cases) between the use of both indices, due to the presence of cross-ownership, and less

relevant distortions (less than 10% on average) attributable to the exact definition of control used in each case.

Of course, our implementable generalized index requires in practice a more detailed review of the ownership and control mechanisms in any industry under scrutiny, and its computing costs are always higher than the simple square sum of market shares. However, the *GHHI* retains the strong theoretical foundations of the *HHI* and its easy economic interpretation. If ignored, the evaluation of concentration levels in industries with cross-ownership through the *HHI* would mislead the connection between structure and conduct – between the competitive characteristic of a market and the behavior of the firms in it – thus breaking one of the most important industrial organization paradigms, which often gives rise to many antitrust cases. Therefore, as a final policy implication, this paper shows that governments and competition agencies should pay more attention to the cross-interests that relevant groups of investors share in strategic sectors¹⁷, in order to keep competition policy tuned.

7. References

- Arthur, N. (2001), “Board composition as the outcome of an internal bargaining process: empirical evidence”, *Journal of Corporate Finance*, 7, 307–340.
- Atienza, L., J. de Quinto y R. Watt (2001), “Análisis de los efectos económicos y sobre la competencia de la fusión *Endesa-Iberdrola*”. *Documento de Trabajo*, Universidad San Pablo-CEU. Instituto de Estudios Europeos, Madrid.
- Bresnahan, T. and S. Salop (1986), “Quantifying the competitive effects of horizontal joint-ventures among competitors”, *International Journal of Industrial Organization*, 4, 155–176.
- Crespí-Cladera, R. and García-Cestona, M.A. (1998), “Ownership and control: a Spanish survey”, *mimeo.*, Universidad Autónoma de Barcelona.
- Demsetz, H. (1973), “Industry structure, market rivalry and public policy”, *Journal of Law Economics*, 16, 1–10.
- Demsetz, H. and K. Lehn (1985), “The structure of corporate ownership: causes and consequences”, *Journal of Political Economy*, 93, 6, 1155–1177.
- García-Díaz, A. and P. Marín (1998), “Market power in the Spanish electricity industry: a simulation”, *Electricity in Europe in the 21st century: What performances and what game rules?*, International Conference, Paris. November 1998.
- Jensen, M. and J. Warner (1988), “The distribution of power among corporate managers, shareholders, and directors”, *Journal of Financial Economics*, 20, 3–24.
- Leech, D. (1987), “Ownership concentration and the theory of the firm: a simple-game-theoretic approach”, *The Journal of Industrial Economics*, 35, 3, 225–240.
- Leech, D. (1988), “Relationship between shareholding concentration and shareholder voting power in British companies: a study of the application of power indices for simple games”, *Management Science*, 34, 4, 509–527.
- Leech, D. and M. Manjón (2001), “Corporate governance theoretic analyses of shareholder power: the case of Spain”, *mimeo.*, Universidad Rovira i Virgili.
- Levy, H. (1982), “Economic evaluation of voting power of common stock”, *The Journal of Finance*, 38, 1, 79–93.

¹⁷ In November 2001, when this paper was concluded, the Spanish government limited the extent of cross-ownership in energy and telecoms to 3%, as a mechanism to favor competition in these sectors.

- Maxwell, C., D. O'Brien and J. Parsons (1999), "Measuring concentration in the presence of cross-ownership: solutions and problems", *mimeo.*
- Manjón, M. (2001), "Power and risk factors in the ownership concentration mechanism", *mimeo.*, Universidad Rovira i Virgili.
- Reynolds, R. and B. Snapp (1986), "The competitive effects of partial equity interests and joint-ventures", *International Journal of Industrial Organization*, 4, 141–153.
- Rydqvist, K. (1992), "Dual-class shares: a review", *Oxford Review of Economic Policy*, 8, 3, 45–57.
- Saving, T. (1970), "Concentration ratios and the degree of monopoly", *International Economic Review*, 11, 139–46.
- Schmalensee, R. (1977), "Using the H-index of concentration with published data", *Review of Economics and Statistics*, 186–193.
- Shapley, L. (1953), "A value for n -person games". En: H. Kuhn and A. Tucker (Eds.), *Contributions to the Theory of Games. Annals of Mathematics Study*, 28, 307–317. Princeton University Press, Princeton.
- Shapley, L. and M. Shubik (1954), "A method for evaluating the distribution of power in a committee system", *The American Political Science Review*, 47, 3, 787–792.
- Straffin, P. (1977), "Homogeneity, independence, and power indices". *Public Choice*, 29, 107–118.
- Kelly, W. (1981), "A generalized interpretation of the Herfindahl index", *Southern Economic Journal*, 48, 1, 50–57.
- Zingales, L. (1995), "What determines the value of corporate votes?", *The Quarterly Journal of Economics*, 8, 4, 1047–1073.