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Laboratoire d'Analyse économique des Réseaux et des Systèmes Energétiques

Working Paper n°21

March 2009

HHI, an irrelevant market indicator without a relevant market

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Summary. For evaluating the concentration effects of horizontal unbundling or mergers in the electricity industry a one-number-indicator is desirable. But, the three most widely applied measures (HHI, PSI and RSI) are per se unable to represent changing sizes of the relevant market due to occasional congestion as they often occur in electricity markets. This paper proposes an adjusted HHI taking into account wider-then-national markets as well as time varying degrees of international competitive pressure. The corresponding adjusted HHI for the French market is 3200 and thus significantly below the HHI of the pure national market (6500).

[1] LARSEN. We would like to thank Dominique Finon for critical remarks. All remaining errors are in the sole responsibility of the authors. www.gis-larsen.org.

1. Introduction

The literature provides several indices of the concentration degree in electricity markets. The most commonly used are the Herfindahl-Hirshmann Index (HHI), the Pivotal Supplier Index (PSI) and the Residual Supplier Index (RSI).[1] Yet, most energy economists would agree that the HHI (as well as the PSI and the RSI) are poor measures of the concentration degree in electricity markets for various reasons: they ignore internal congestion, they ignore vertical integration, they do not take into account the merit order (i.e., the non-linear cost curve of electricity production), etc. Furthermore, much more advanced techniques that cope with certain of those issues exist.[2] Nonetheless, the desire (of policy makers and lawyers) for a one-number-summary of market concentration has driven a broad usage of those indicators. Especially the HHI has been applied and presented in the EU Sector Inquiry, the EU Benchmark reports as well as in certain lawsuits.[3] Thus, the economic foundations of key assumptions required to calculate these indicators should be carefully checked.

One factor that is central for all market concentration measures is the definition of the relevant market. Due to the high volatility of demand, the non-storability of electric energy and the technical limitations of the transmission network, the size of the relevant market in the electricity sector might change from hour-to-hour. Because the corresponding HHI is as volatile as the relevant market, this concentration indicator would loose much of its appeal. In this paper we propose a pragmatic approach to calculate a one number HHI for a certain core market that takes into account the competitive pressure from adjacent markets (with which it forms a relevant market part of the time). In the next section the adjusted HHI is introduced. The third section presents the data of our case study (France) and in the fourth section the adjusted HHI is calculated for the French market. The fifth section concludes.

2. The international trade adjusted HHI

A relevant market is defined as the geographic area in which a producer effectively competes with producers of the same product and producers of substitutes.[4] This theoretical definition is not easily translated into clear market boundaries of real-world electricity markets.

The question “which regions generators might exercise competitive pressure on a producer?” could be sensibly addressed only by profound modeling. But, building oligopolistic models that replicate all important characteristics of electricity markets has proven difficult. Including highly volatile demand, network characteristics, market mechanisms, forward markets, congestion management mechanisms, etc. in one

[1] The Herfindahl-Hirshmann index (HHI) is defined as follows: $HHI = \sum (MS_i)^2$, where MS_i is the market share of firm i. It measures the degree of concentration in a given market. The maximum value (monopoly) of the HHI is equal to 10000.
[2] E.g. Oligopolistic models of Cournot or Supply function equilibrium type allow a much deeper understanding of the competitive effects of mergers or divestitures.
[3] European Commission (2005, 2006, 2007) and see Vandezand et al. (2006).
[4] Assuming that electricity, at least in the current price region is difficult to substitute in the short- to mid-term we focus on geographic competition relative to product substitutes competition (natural gas for example).

single model is very challenging.[1] Consequently, simple initial indicators concerning the size of the relevant market remain desirable.

Thus, a set of pragmatic approaches have been proposed. According to Vandezand et al. (2006) in past cases the EU Commission used certain “rules of thumb” relying on the occurrence of congestion and price differences as well as the relative size of the interconnectors for determining market definitions.[2] The Sector Inquiry[3] proposes that the relevant market might be formed by the domestic market plus the capacity of the transmission lines. [4] Further “rules of thumb” have been proposed by other authors.

As has been discussed by Dijkgraaf and Janssen (2008) the relevant electricity market are rather “flighty”. On the example of the French-Belgian-Dutch trilateral market coupling, they show that certain periods exist, where these three markets form a common “relevant” market. In presence of congestion, however, the market splits and the relevant market shrinks to a bilateral or unilateral market. Both, extensive oligopolistic modeling and “rules of thumb” do not take into account the “flighty” nature of electricity markets. Even if different market sizes for different demand scenarios are calculated, conveying the results to the addressees is difficult. Stating that Polish producer might exercise competitive pressure on prices in Spain in certain hours of the year but that Austrian power plants do not in all cases compete with German ones leaves lawyers uncertain of what to make of these results. Thus, a one-number summary that indicates the competitive situation in the core market, taking into account the occasional coupling with adjacent markets would be desirable. Vandezand et al. (2006) suggest that it is possible to calculate HHIs based on two extreme market definitions. Using certain additional indicators (congestion, price differentials) they propose that one might interpolate a definitive result in-between the smallest and the largest market definition.

This method lacks three important qualities for indicators: transparency, reproducibility and simplicity. We therefore propose an alternative approach. The idea is that an adjusted HHI for one core market can be calculated taking into account the hourly changing occurrence of congestion at its borders. This concentration indicator is based on weighting the concentration indicators for different market combinations with their respective frequency of being “relevant”.[5] Hence, the different competitive effects of export and import congestion are taken into account.

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[1] Using these “structural” models it is possible to deduce the size of the relevant market by estimating whether the strategic choice of a generator is affected by the potential reactions of a competitor or not. In the first case the competitor is part of the relevant market, in the second it is not.

[2] A wider than national market is an acceptable assumption if: interconnection capacity > 25 percent of national consumption; congestion level < 5 percent; price differences occurring < 10 percent of the time. A wider than national market is not an acceptable assumption if: interconnection capacity <10 percent of national consumption; congestion level > 25 percent; price differences occurring > 50 percent of the time (see Vandezand et al. (2006)).

[3] European Commission (2007).

[4] There is a theoretical difficulty with this approach as transmission lines might either be considered as consumer (export) or producer (import). Thus, a transmission line towards a low generation cost country might increase competition while a connection with a high cost country might curb competitive pressure if interconnector allocation is performed through a competitive mechanism that prohibits withholding.

[5] See the example in the Appendix.

In the case of export congestion, the HHI corresponds to the HHI in the core market. By way of contrast, in the case of import congestion the competitive pressure of foreign generation is limited to the size of the corresponding interconnector attributed to generators according to their foreign market share (See Table 1).

Doing this analysis for a real-world case thus requires two steps: First the concentration indicator for each feasible grouping of markets (that include our core market) has to be calculated. And second, the frequency at which each market group is relevant (i.e., the biggest joint market) has to be calculated.

Table 1: Two Country Example for calculating the adjusted HHI

	Generation Capacity of Company A	Generation Capacity of Company B	Generation Capacity of Company C	Size of the relevant market	Frequency of occurrence	HHI
Domestic	90 GW	10 GW	0 GW	100 GW		**8200**
Foreign	10 GW	0 GW	40 GW	50 GW		**6800**
Coupled	100 GW	10 GW	40 GW	150 GW	40%	**5200**
Import Congestion (10 GW line)	92 GW	10 GW	8 GW	110 W	40%	**7131**
Export Congestion	90 GW	10 GW	0 GW	100 GW	20%	**8200**
Total						**6572**

This requires defining when a group of markets can be considered as coupled. Markets can be said to be coupled if price (or volume) changes in one market are transferred to the other market. Thus, a market player in one country has to take into account the response on his price/volume decision in the other country. To decide whether two markets are coupled or split, one might either consider physical or financial indicators. If available transmission capacity is not fully used, two markets might be considered coupled.

This physical approach, however, requires full knowledge of the available capacity (including loop flows, reliability margins in transmission capacities etc.). Furthermore, under- or over-utilization of transmission lines with respect to price differentials are very common in Europe. If prices in two interconnected regions are similar, this is a strong indicator that those two markets are coupled.[1]. Thus, we assume market coupling if the price difference is below 5%.[2] With this definition in hand we can calculate the historic frequency of market coupling for each market combination. Combining these with the corresponding HHIs allows computing the synthetic HHI for country j (HHI_j).

[1] A reservation has to be made: Remaining price differentials might not necessarily indicate a splitting of markets but they can also be due to the decentralized price formation in power exchanges and explicit capacity auctions. In fact, penny-sharp arbitrage takes rarely place even in completely integrated markets. Such deviations will abate as market coupling develops.

[2] The threshold is borrowed from the "Small but Significant and Nontransitory Increase in Price" test but remains somewhat arbitrary. Thus, the corresponding assumption has to be made explicit in a corresponding analysis. In our case study a 10% reduction in the threshold (to 4.5%) increases the HHI by 2.5%.

The HHI_j can thus be calculated according to :

$$HHI_j = \frac{1}{T}\sum_{t=1}^{T}\left(\sum_{k=1}^{K}\left(100 \times \frac{\sum_{i=1}^{n} GenCap_{k,i} \times coupling_{i,t}}{\sum_{k=1}^{K}\sum_{i=1}^{n} GenCap_{k,i} \times coupling_{i,t}}\right)^2\right)$$

Where $GenCap_{k,i}$ is the generation capacity of company k in country i and $coupling_{i,t}$ is defined according to :

$$coupling_{i,t} = \begin{cases} 1 & \text{if} \quad -5\% \times price_{j,t} < \left(price_{i,t} - price_{j,t}\right) < 5\% \times price_{j,t} \\ 0 & \text{if} \quad price_{i,t} - price_{j,t} \geq 5\% \times price_{j,t} \\ \frac{tc_i}{\sum_{k=1}^{K} GenCap_{k,i}} & \text{if} \quad price_{i,t} - price_{j,t} \leq -5\% \times price_{j,t} \end{cases}$$

There, tc_i is transmission capacity of country j with country i and $price_{i,t}$ is the price of electricity in country i at time t.

3. Data

The case study in this paper is focusing on the French and its adjacent markets, Belgium (BE), Italy (IT), Spain (ES), United Kingdom (UK), Germany (DE) as well as the Netherlands (NL).[1] To calculate the HHI according to the methodology above the interconnector capacities between the considered markets as well as the ownership structure of generation assets in those markets are required. The former are obtained in the form of net transfer capacities (NTCs) from the UCTE calculations for Summer 2008 (see Appendix).

The ownership of generation capacities is acquired from the Annual reports of the biggest generators (see Appendix). This means that the competition enhancing effects of smaller generators are not fully represented as those are summarized in a single entry ("other generators"). This, however, only results in a very limited bias as the HHI is by construction dominated by the market share of the big players. Another point worth mentioning is the way we treated cross-ownership. To keep the calculation as simple as possible, only cross-ownerships among the big players are considered, control stakes (>50%) are taken into account as full ownership while non-control stakes (<50%) are ignored.[2] For calculating the coupling frequencies we rely on European electricity spot prices from November 2006 (introduction of trilateral market coupling and the Belgian electricity exchange) to August 2008. We collected hourly data from the Italian, Spanish, German, French, Belgium, Dutch and British electricity spot market. We assume that the spot prices obtained in each power exchange reflect the spot price in all the concerned country.

[1] Note that through this approach apart of the Netherlands third countries (e.g., Portugal, Denmark, Austria …) as well as countries without an hourly spot market (Switzerland) are ignored even though they might form a unique-price-area with France at certain times. Luxemburg is considered as part of the German electricity system with which it is strongly connected.

[2] See Campos and Vega (2002).

4. Results

In Table 2 the results for certain market combinations are presented. It is striking, that the French market is almost never (less than 0.5% of the times) completely split from all its neighboring markets. In fact, in 72% of the cases the trilateral market coupling with Belgium and the Netherlands produces (almost) similar prices in all three countries. Furthermore, also the German (27%), Spanish (16%) and Italian (7%) prices are often (almost) identical to the French price.

Table 2: HHIs and coupling frequencies for selected combinations at 5% price difference 11/2006-08/2008

	HHI	Frequency of this being part of the relevant market	Frequency of this being the relevant market
France	6457	100%	0.47%
France - Belgium	5235	89%	13%
France - Germany	2119	26%	2%
France - Italy	2689	7%	0%
France - Spain	2725	16%	1%
France - Belgium - Netherlands	3975	72%	39%
France - Belgium – Nether. - Germany	1694	21%	16%
France - Belgium - Netherlands - Germany - Italy - Spain - UK	825	0%	0%

From the calculation of the concentration indicators it is obvious that the size of the coupled market significantly influence the HHI. While a truly common market (France - Belgium - Netherlands – Germany - Italy - Spain - UK) produces an HHI as low as 825; the HHI for the "France only" market is at 6457. But both extreme cases were equally unlikely in the observation period. The HHI for the French market adjusted for varying international competitive pressure according to the presented approach is 3218. This is noticeably below the traditionally considered "France only" HHI of 6457. Nevertheless, the still significant amount of the adjusted HHI makes clear that market concentration in France is substantial (>1800) even when taking into account cross-border trade. This is due to the unique position of EdF in the European market, the high concentration in neighboring markets (e.g., Belgium) as well as to the frequent decoupling of certain regions (IT, ES, UK).

But, as the adjusted HHI depends on current coupling frequencies, the high French concentration indicators do not necessarily have to persist forever. The coupling frequencies of Dutch and French prices for example increased from 20% before November 2006 to 72% thereafter.[1] If the planned pentalateral market coupling (BE-DE-FR-LU-NL) is introduced and would be as successful as the trilateral-market-coupling (BE-FR-NL) the French HHI might for example significantly drop. An equal sized increase of the coupling frequencies between Germany and France (currently 26%) might bring the French HHI even below 1800 - the threshold above which a market is generally considered as highly concentrated - as the HHI for the French-German-Belgian-Dutch is 1694.

[1] This is (at least partially) due to the introduction of a trilateral market coupling between Belgium, France and the Netherlands.

5. Conclusion

The HHI is an inappropriate tool to represent the multi-dimensionality of the competitive situation in electricity markets. But these one-number-summaries still play an important role in the political, regulatory and legislative discussion. Thus, their calculation (and interpretation) should take into account main features of this sector. So far, however, international electricity trade and the corresponding competitive pressure have been neglected in the calculation of the HHI. To rectify this situation we propose an HHI that is adjusted for time varying international competitive pressure. This concentration indicator is based on weighting the concentration indicators for different market combinations with their respective frequency of forming a unique-price area with the core market. For the French market the HHI corresponding to this methodology is 3200 (if assuming no congestion if price difference is below 5% of the French price). This is noticeably below the traditionally considered “France only” HHI of 6500. This significant impact demonstrates the capacity of international electricity trade to reduce market concentration. The proposed methodology has various advantages : it is transparent, reproducible, simple and flexible with respect to the analyzed markets. Furthermore, it could be easily adapted for the use with different concentration indicators (e.g., RSI or PSI). The main drawback for calculating the adjusted HHI is that certain assumptions remain arbitrary to some extent. Especially the threshold for assuming price equalization has to be selected with care, documented well and included in the interpretation.

References

Borenstein, S., Bushnell, J., Stoft, S., 2000. The competitive effects of transmission capacity in a deregulated electricity industry. RAND Journal of Economics 31(2), 294-325.

Campos, J., Vega, G., 2002. Concentration measurement under cross-ownership. The case of the Spanish electricity sector. Univ. de Palma - documento de trabajo 2002-06.

Dijkgraaf E., Janssen, M., 2008. Is there a Belgian Wholesale Electricity Market? Erasmus Competition and Regulation Institute.

European Commission, 2005. Report on progress in creating the internal gas and electricity market (Benchmarking report). Communication from the commission to the council and the European Parliament COM (2005) 568 final Brussels, 15.11.2005.

European Commission, 2006. Report on progress in creating the internal gas and electricity market (Benchmarking report). Communication from the commission to the council and the European Parliament COM (2006) 841 final Brussels, 10.01.2007.

European Commission, 2007. Report on energy sector inquiry (Parts 1,2,3,4), DG Competition, Brussels 10.11.2007.

ETSO, 2008. Online data on the Net Transfer Values are downloaded from [http://www.etso-net.org/NTC_Info/library/e_default.asp].

Vandezande L., Meeus, L., Delvaux, B., Van Calster, G., Belmans, R., 2006. Evaluation of Economic Merger Control Techniques Applied to the European Electricity Sector. The Electricity Journal 19(6).

Appendix

Table 3: Matrix of biggest Producers : installed production capacities (GW)

	FR	DE	BE	NL	LU	IT	ES	UK
ATEL	0.8							
EDF	92.5		0.4					4.8
EnBW		15.0						
E.on	3.3	26.2		2.0		6.6	3.8	9.8
RWE	0.8	31.7			1.1			10.6
Vattenfall	0.8	15.2						0.09
Poweo	0.3							
Direct Energie	0.3							
GDF/Suez	7.8	0.3	12.9	4.7	0.4		1.2	0.18
EWE (ENR)		0.7						
ESSENT				5.1				
Nuon				4.1				
SPE			1.6					
Cegedel					0.2			
Iberdrola							27	
EDP							3.8	
Gaz Natural							4	
ENEL (incl. Endesa)	1.0					40.4	17.6	
edison						12.0		
ENIPower						4.5		
Scottish Power								6.35
SSE								9
DRAX								3.9
British Energy								10.7
Centrica								3.5
Inter. Power Mitsui								5
Others*	8.5	35.2	1.2	6.2	0.0	25.6	21	14

* "Others" is the difference of total installed capacity minus the capacity of the biggest generators. "Others" are attributed to each country as a different company.
Sources : Companies Annual Reports and OFGEM.

Table 4: Net Transfer Capacities Values for Summer 2008 (MW)

	From France	To France
Germany	2400	2500
Belgium	2700	1100
Netherlands	2000	1100
Austria	1000	800
Spain	1200	500
Italy	2400	870
UK	2000	2000

Source: ETSO 2008 - non-binding peak values