Transmission Network Unbundling and Grid Investments: Evidence from the UCTE Countries

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Abstract

Mainstream economics suggest that investments in the electricity transmission grid aiming to increase its capacity (and quality) affect positively the level of competition in both the wholesale and the retail markets (Arellano and Serra, 2008; Borenstein et al., 2000; Léautier, 2001). Thus, vertically integrated companies have no interest in investing and increasing grid capacity (Boyce and Hollis, 2005): unbundling of both the transmission (TX) network and the interconnections (ICX) can be seen as a structural solution to this vicious circle (Brunekreeft, 2008; Pollitt, 2008). The EU decision to unbundle electricity transmission network relies on this simple framework. Other scholars point out that benefits have to be compared to costs of unbundling (Arocena, 2008; Chao et al.*, 2008; Kaserman and Mayo, 1991; Kwoka, 2002). Consequently, this paper will propose an empirical analysis to evaluate whether, and to what extent, unbundling measures had any impact on the increase of grid investments, focusing on UCTE countries between 2000 and 2006. Results show that unbundling cannot be related to an improvement of the grid, above all to its quality performance: this analysis show mainly an enlargement of the grid at the peripheries, but not a substantial enforcement of the grid, in order to guarantee the sustainability of the flows of electricity. In case of ownership unbundling not only there are no higher investments in the network, but also a lack of quality emerges, so that twisted results can be put in evidence and doubts on the EU policies could be moved. The general indifference to the degree of concentration of the market, whereas a strong impact in concentrated markets was expected, is quite surprising.*

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1. Introduction

Based on an analysis of mainstream economics, this paper accepts the hypothesis that investments in the grid which aim at increasing its capacity (and quality) affect positively the level of competition in both the wholesale and the retail markets. Thus, generation companies currently owning the grid are supposed to have no interest in investing and increasing grid capacity: unbundling of TX network can be seen as a structural solution to this vicious circle. On the other hand, unbundling imply some costs, essentially due to economies of coordination in vertically integrated system. To date, scholars have yielded empirical evidence on the relation between regulatory reforms in general (liberalization, privatization) and the electricity system, mainly wholesale and retail markets, but, as Pollitt argues, '[t]he lack of definitive econometric evidence on reform effects […] clearly illustrates the need for further work on this now that we have more experience of reform. However the problems of co-incidence with other reform steps and difficulties in modelling underlying resource costs will continue to be an issue.' (2008: 709; also Michaels, 2006). Henceforth, this work desires to be a contribution to fill this gap, focusing on the specific role of unbundling on transmission and interconnection investment and operation among the electricity subsectors.

Notwithstanding their small incidence on the final costs, between 5% and 10% in OECD countries (IEA, 2002: 49-50), the TX and ICX are essential for the electricity supply (Joskow and Schmalensee, 1983; IEA, 2002). The EU is currently affected by an underperforming level of investments in the grid (TEN-E Guidelines, 2003; Priority Interconnection Plan, COM(2006)846), and delays in the ongoing projects (MVV Consulting Report, 2007; SEER2; COM(2008)770; COM(2008)782). To provide a measurement of this gap, the UCTE Development Plan 2008 estimates the necessary investments for both grids and interconnections in 17 billions € of overhead lines for the following 5 years. According to EC's third package on energy sector and the previous documents, gaps in grid investments are essentially due to the conflict of interest of the vertically integrated incumbents, which aims at preserving concentrated and national markets (COM(2007)1). Network unbundling is proposed as the right solution to encourage new investments, notwithstanding the opposition of some important MS (Sioshansi, 2008b; Van Koten and Ortmann, 2008). After describing some aspects of the debate (section 2), this paper proposes a literature review about the assessment of transmission network unbundling's impacts, showing direct and indirect benefits and costs, and the emerging ambiguity in results (section 3), an empirical analysis is proposed, focused on UCTE (Union for the co-ordination of transmission of electricity) countries between 2000 and 2006 (sections 4 and 5). On the base of this evidence, a general assessment of the unbundling reforms is provided and some policy advices for the EU energy policy are suggested (section 6).

2. The third package: a brief introduction

Description of the dynamics occurred from 2007 to 2008 help to focus not only the facts characterizing the legislative route, but also, and mainly, to put in evidence the emergence of geopolitical issues beside to the conventional wisdom in order to explain the roles played by the EC, MS and utilities.

2.1. The steps before the third package

The EC stepped towards the EU energy “third package” on January 2007 with a set of documents, including 1) an assessment of the implementation of previous EU reforms in the MS and their impact to date (Final Report of the Sector Inquiry), 2) an analysis of the three pillars the EU energy policy should be based on (COM(2007)1), and 3) the proposal to introduce OU as the right solution to the problems of lacking competition; legal and functional unbundling have been considered to give a positive, but not sufficient contribution to achieve EU energy policy goals. In a nutshell, higher competition would have implied decreasing prices, promotion of investments, a higher integration of the electricity grids among MS and, consequently, a major role for the EU polity in leading energy sector.

The EC’s decision to proceed firmly on this policy was confirmed and strengthened by the following Spring European Council, where OU was essentially encouraged. On that occasion, President Barroso could affirm that ‘the status quo is not an option [...] that is very clear’ (Financial Times, FT, March 12th 2007); notwithstanding the substantial invitation to the EC to confirm its proposal in a new directive within the next months, the Presidency conclusions did not exclude that a strong regulation, without any further intervention to unbundle network and generation, could have been enough (regulatory unbundling). On June, during the European Council of Energy Ministers, two coalitions clearly emerged, so that Commissioner Piebalgs admitted it was a ‘very, very uneasy situation’ (FT, June 6th 2007). Sceptic positions, led by Germany and France, included also Austria, Bulgaria, Slovak Republic, Greece, Luxemburg, Latvia and Cyprus, converging on two beliefs on OU, that are: 1) the absence of evidence of better performances in unbundled electricity markets; 2) the increasing risk that an unbundled transmission company (Transco) might be taken over by foreign (extra-EU) companies. This latter point, encouraged by a clear strategy pursued by Russian Gazprom, was even more concrete in the gas sector: Russian players, as well as sovereign funds could enter the national markets and acquire its (politically and economically) strategic assets. On the other hand, it was probably the emerging opposition to unbundling measures which encouraged eight countries, including Denmark, the Netherlands, Belgium, Finland, Sweden, Spain, the United Kingdom and Romania, to send an official letter to Commissioner Piebalgs to sustain EC's position. The resolution European Parliament approved on July 10th 2007 considers ownership unbundling 'to be the most effective tool to promote investments in infrastructures in a non-discriminatory way, fair access to the grid for new entrants and transparency in the market'; at the same time the resolution declares 'that this model might not address all of the issues at stake such as interconnections or congestion points', showing a compromise resolution due to the keen scepticism emerging among MS on the Commission position.

2.2. The proposal of the third package by the EC

On September 19th the EC proposed the so called "third package" promoting (1) an effective OU, although ISO model is still accepted; (2) the creation of an Agency of the Cooperation of the Energy Regulators (ACER); (3) a more effective coordination among the European Networks Transmission System Operators (ENTSO). It has been considered as a compromise due to the recognition of a sort of two speed route. Beside the confirmation of OU as preferred solution, the ISO model, quite spread in the USA was suggested as a second-best, admitting the vertically integrated incumbent to keep the ownership of the assets, but introducing an independent player to operate the network. At the same time a safeguard clause (so called Gazprom clause) was introduced in order to guarantee the EU control on 'both its direct and indirect independence from supply and generation activities' (Explanatory Memorandum, 1.3) of any purchaser of a EU grid: in particular, it requires 'the effective unbundling of transmission system operators and supply and production activities not only at national level but throughout the EU. It means in particular that no supply or production company active anywhere in the EU can own or operate a transmission system in any Member State of the EU. The requirement applies equally to EU and non-EU companies [... and] in the event that companies from third countries wish to acquire a significant interest or even control over an EU network, they will have to demonstrably and unequivocally comply with the same unbundling requirements as EU companies' (*ibidem*).

France and Germany, still not satisfied by the solution EC had proposed, tried to organize and suggest an alternative proposal to the EC: after being accused to implement a delaying tactic, waiting for the conclusion of both EP and Commission terms (first semester 2009), on January 29th 2008 the group of eight sceptics (above mentioned, excluding Cyprus) sent a missive to Mrs Niebler, ITRE (Industry, Research and Energy Committee) Chairwoman. The alternative proposal introduced the option of the Effective and Efficient Unbundling (EEU), which essentially would guarantee the *status quo* of VIUs, although in presence of a quite stronger regulation. At the end of February 2008, the EC rejected this proposal and confirmed the third package previsions.

After German and French proposal had been rejected by the Commission, at the end of February the Council of the Energy Ministers substantially confirmed the EC's position, as the European Council did on June 2008. At the same time, probably in connection with this decision, the CEO of the German E.ON, one of the most relevant VIUs in the European energy markets, announced the decision to unbundle its grid in Germany, determining negative comments from other integrated utilities and, even, the German Government. Notwithstanding this important step, up to date E.ON still owns its grid

After a first approval by the EP, the second reading has occurred on last April 22nd. The obligation of ownership unbundling has mitigated by introducing also ISO and EEU solutions.

3. Studies on network unbundling

It is well acknowledged that investments in TX and ICX capacity can have a positive effect on the reliability of the entire system, mainly because their impact can contribute to increase the quality of the grid so as to decrease disturbances and the volume of energy not supplied. Nevertheless, this analysis will focus on the relation between TX and ICX constraints and competition in wholesale markets, which the recent EU energy policy, as previously shown, relies on.

3.1. Pro-competitive effect of investments in TX capacity

Borenstein *et al.* (2000) show theoretically how TX constraints badly affect consumers' surplus, and increase the firm's one: in a model of two geographically distinct markets, each dominated by a single generator in a monopolistic equilibrium, a new TX line connecting the markets determines a shift towards an unconstrained Cournot duopoly equilibrium. Léautier (2001) widens the previous model. A three-node network is introduced with two generators and a consumer linked by a loop: in the model, a benevolent TX system operator plans and allocates generation between the two gencos at time 0, considering the physical constraint in the grid. In absence of regulation on prices, a TX capacity increase affecting the constraint determines a double impact: first of all a 'substitution effect' consisting in the replacement of units of electricity from the more expensive generator to the cheaper one, re-allocating both the volumes of supply previously fixed by the planner and, consequently, their surplus. Together with this impact, a 'strategic effect' emerges: a price-shedding effect affects the distribution of surplus not only among generators (as in substitution effect), but also between consumers and suppliers, generating more consumers' surplus: lower market power determines lower prices, due to a pro-competitive impact on the wholesale markets. Confirms emerged in Quick and Carey (2002), by simulating a TX expansion in the Colorado electricity market. Similar conclusions have been found in case of price regulation: Arellano and Serra (2008) confirm the impact of TX expansion on competition in a price-regulated wholesale market with an inelastic demand and a planner (an ISO) which allocates generation so as to minimize costs and which sets prices. Incumbent, who cannot decrease prices, organizes its energy mix so as to increase efficiency. Summarizing, TX capacity expansion stimulates competition among generators through strategic and substitution effects either affecting prices (in deregulated markets) or generation portfolios (in price-regulated markets), although it will depend on the dimension of the previous capacity, heterogeneity of demand, energy mix, and finally on the degree of competition of neighbour regions (Küpper *et al.*, 2009: 33).

3.2. Unbundling as a structural solution to the conflict of interest of VIUs

The structural (or systemic) conflict of interest, as expressed in COM(2006) 851 (n.52), has been explained by Léautier (2001) who stresses the lack of incentives for generators to invest in TX capacity increase. In fact, vertically integrated utilities are aware that the substitution and strategic effects due to TX capacity increase would limit their market power in the local or national wholesale electricity markets, and might thus strategically under-invest (also in Boyce and Hollis, 2005; Minoia *et al.*, 2006; Sauma and Oren, 2006). Two main approaches have been focused on in order to solve the negative consequences of the conflict between gencos' and transcos' interests on grid investments: it is possible to distinguish between short run behavioural measures and long run structural measures. Among the formers, there is a stream focusing on transmission property rights (Joskow and Tirole, 2000; Gilbert, Neuhoff and Newbery, 2004); other scholars underline the role played by a stronger regulation (Kwoka, 2002; Sappington, 2006). Notwithstanding the positive effects of these solutions, they do not solve for good the consequences of the incumbents' conflict of interest. A structural remedy, on the contrary, would affect the natural opposition of gencos in investing in the grid. Léautier (2001) suggests unbundling as the right, structural solution to solve this problem. Among the different levels of unbundling which can be introduced in the market, accounting, functional and legal unbundling, the ownership unbundling, requiring the transco not to be owned by the genco is supposed to show the highest positive relationship with grid investments (Boyce and Hollis, 2005; Cremer *et al*., 2006; Pollitt 2008).

3.3. Costs of unbundling transmission network

Beside the previous literature promoting unbundling as an investment-enhancing policy, other scholars have been defending vertical integration in the electricity industry, identifying some evidences of economies of vertical integration among generation and transmission. Pioneers in this field, Kaserman and Mayo (1991) adapted a multiproduct cost function to the vertical structure of the electricity industry, trying to show the existence of 'multistage cost' economies to be preserved from de-integration; they tested this model on a sample of 74 US private owned electricity monoutilities, concluding that 'the results provide empirical evidence of the existence of significant vertical economies between the generation and distribution stages of electricity supply [so that] … the evidence presented does place a heavy burden on proponents of deregulation schemes that are premised upon forced vertical divestiture in this industry' (1991: 500). Confirmations arrive from D'Aveni and Ravenscraft's comparison between multiproduct cost economies and bureaucracy costs in vertical integrated firms (1994); Delmas and Tokat (2005), testing on 177 US electricity firms between 1998 and 2001; Greer (2008) analyzing cost functions of the rural electricity firms, mainly cooperatives. Outside of the US, Nemoto and Goto (2004) found cost savings from economies of coordination between 0.13 and 2.97% in Japan; in Spain, Jara-Diaz *et al.* (2004) valued 6.5% of savings, while Arocena (2008) shows an impact between 1.1 and 4.9%; Fraquelli *et al.* (2005) found 3% out of the costs in Italy.

Economies of coordination do not include exclusively multiproduct cost economies, as Kwoka clearly points out (2002; 2008). He recognizes the existence of multiproduct cost economies, but also takes account of transaction costs economies between generation and transmission, as emerged in its test on a set of 147 electricity utilities. Consequently, he proposes a wider catalogue of these economies of coordination (Kwoka, 2002: 655). Economies of transactions in grid investments are essentially due to their nature of sunk costs. The genco to be connected has to guarantee the supply of electricity in order to make this investment profitable and not useless for the transco. Different owners, of course, make these expectations more uncertain: an expensive contract, with high asymmetric information, is to be signed between generation and transmission companies, whilst integration could avoid these transaction costs. Other examples on the role played by the economies of coordination can be found in Arocena (2008), who identifies positive impacts in vertical integration not only in cost savings but also in increased quality of the service. Connected to this last element, Jamasb and Pollitt (2008) hypothesize that the lack of investments in R&D emerged in the last decade is also due to reforms including unbundling. Also a problem of allocative efficiency arises: in absence of a clear regulation, there is a risk of 'double marginalization' by the two or more different unbundled firms (gencos and transco) instead of the previous single incumbent (Baarsma *et al.* 2007). As also the institutional framework does matter, Baarsma *et al.* (2007) include as well the risk that de-integrated (and less capitalized) firms might be taken over by foreign utilities, with a noxious effect on energy independence and supply security (also in Thomas, 2007b), showing the emergence of geopolitics issues which are strictly related, in the case of the EU energy policy debate, to the economic issues. Künneke and Fens (2007) recognize a problem of supply security in case of de-integration, although they do not consider as an option to preserve vertically integrated companies: they suggest that in a context of privatization in the wholesale and retail electricity markets, (ownership) unbundling, even showing costs for welfare, could be a way to preserve TX network under public ownership, whereas generation is going towards a process of concentration at European level. It is indirect evidence that unbundling, if not associated with public ownership, could determine a problem of energy dependency from foreign or private for profit owners. Moselle (2008) analyzes risks connected to unbundling and argues that even inside the same TSO a conflict of interest could emerge between the two roles of transmission operator (TO) and system operator (SO), requiring further regulation (also in Van Doren and Taylor, 2004). There are also interesting findings in Glachant and Lévêque (2006) and Chao *et al.* (2008), which underline the role of finance and investment in the electricity sector and, thus, suggest that for financial actors 'vertical integration is the best protection against volatility and the cyclical nature of markets' (Glachant and Lévêque, 2006: 10).

In general terms, the property rights literature shows that vertical integration (Grossman and Hart, 1986) may (or may not) be a second best solution because of the inherent incompleteness of contracts. As in Michaels (2006), the interconnection between de-integration and other factors including the system operator, the condition of competition in the wholesale market and the access to the market of the consumers, should be assessed, because it is the entire system which guarantees reliability.

3.4. An unclear net impact: the role of empirical evidence

A deeper analysis of both benefits and costs of unbundling and, namely, ownership unbundling is in Pollitt (2008) and Brunekreeft (2008). They also conclude their taxonomy of impacts that both TX network unbundling and vertical integration have an ambiguous net effect on welfare (other contributions are in Michaels, 2006 and Brennan, 2006). An assessment on the empirical effect of ownership unbundling misses, according to Baarsma *et al.* (2007). The mixed findings, emerging from theories and models, require an analysis of the evidence emerging in different countries where reforms have been implemented, including unbundling, during last years. Thus, besides mono-country analyses, already mentioned above, a cross-country approach can be argued to be more adequate to identify similarities in different contexts, and, as a result, to justify wider conclusions. So far, albeit many scholars recognize a specific role of transmission network unbundling, their analyses point out the effects on the electricity market as a whole, or mainly generation but not transmission *per se*. Steiner (2000) and Hattori and Tsutsui (2004), based on a sample of OECD countries, focus on the relation between unbundling and the retail prices of electricity, but no evidence concerning impacts on the TX capacity or quality is brought. Also Alesina *et al.* (2005) shows clear evidences of positive impact of reforms on investments: their database, concerning 21 OECD countries between 1975 and 1998, include data on regulatory aspects (access to the grid, vertical integration and public ownership) organized in 4 different indicators and on investments in utility sector; notwithstanding the empirical approach, there is no distinction between water and energy sector, thus nothing specific about impacts of reform on TX system emerges.

3.5. Research hypotheses

After a decade of proposed and implemented unbundling policies, it is eventually possible, albeit preliminarily, to assess their impact on the electricity sectors. Studies on consequences of unbundling on the wholesale and retail markets, as already said, are numerous and rather exhausting on this topic: what the debate needs is an assessment of capacity and quality of the national grid and interconnections. On the base of these previous arguments, it is clear that the research hypotheses relate to the assessment of evidences of higher investments in TX and ICX capacity and quality, identifying possible connections with the ongoing process of unbundling that characterizes most of the analyzed countries in the period 2000-2006. Obviously, as mentioned above, unbundling measures can be introduced into different ways and with different effects on the level of vertical integration of the incumbents. A dichotomy has been introduced to distinguish unbundled markets (U) in general (whatever level of unbundling has been implemented: ownership; legal; account and functional) and ownership unbundled markets (OU). Thus, synthetically, this work aims to verify whether:

- the TX and ICX networks that have been unbundled show a greater growth of capacity and a higher quality than not unbundled electricity markets; and, in particular
- the TX and ICX networks that have been ownership unbundled show a greater growth of capacity and a higher quality (less disturbances) than all the other electricity markets.

In the approach *à la* Léautier, unbundling is implemented in presence of a vertically integrated incumbent who has not sufficient incentives to invest in the network. Hence, there is a second strong hypothesis to be verified: it could be supposed that a positive relation between unbundling and grid investments might be more evident where the level of market power of the wholesale market is higher and the incumbent's market power stronger. On the contrary, where competition in the market is established, there could be minor evidence: incentives to discriminate rivals could be smaller as network capacity could have already adapted. Consequently, concentration of the wholesale markets has to be considered, namely if markets are concentrated or not (in case of TX networks); or if both the interconnected countries are concentrated or not (for ICX networks). Henceforth, hypotheses to be verified will include that in case of concentrated wholesale markets:

- the TX and ICX networks that have been unbundled are more likely to show a greater capacity and higher quality;

- the TX and ICX networks that have been ownership unbundled are more likely to show a greater capacity and higher quality.

4. Empirical strategy

The statistical analysis aims to be a first step into this research field: it could be defined as an exploration inside the general trend characterizing the physical and qualitative development of the TX and ICX systems before and after the introduction of the unbundling measures into the national electricity sectors.

4.1. Indicators

Most of scholars use monetary values. Alesina *et al.* (2005) chooses monetary proxies (investments, gross capital stock, and value added at the country-sector-year), taken from the OECD STAN database, but, as already said, values in that case include both water and energy, without any possibility to distinguish electricity. As well as OECD, most of the other international institutions, including the International Energy Agency (IEA) do not provide any database concerning monetary expenditures in TX grids and ICX. On the other hand, balances of the main national companies could have been collected and analyzed: this approach would have reduced the breadth of this research, as monetary values cannot be easily collected for a sufficient group of firms through their annual reports: balances are available on line only for few cases and for the latest years; they are not always available online in other languages but the national one, and even if they were, often these documents do not clarify the destination of the investments; in case of vertically integrated firm this makes quite difficult to analyze data. Finally, it could be argued that physical rather than monetary values get real of the problem of potentially inefficient investments, by coupling the grid improvements. Consequently, it has been decided to focus upon techno-engineering indicators which provide information on the extension and quality of the grid (tables 1 and 2). Both for TX and ICX it is noteworthy that quality indicators on disturbances provide also a measure of capacity: disturbances due to failures of the system often depend on bottleneck of the grid, which are a sign of not adequate capacity. Regulatory indicators (table 3) for each country have been chosen in order to estimate:

- level of unbundling in the electricity sector;
- concentration of the wholesale market.

4.2. Data sources

Whilst monetary data on grid investments are not always available, data concerning physical aspects and qualitative performance of TX network and ICX are more easily available, but no international database collects and organizes them, so they are raw. OECD, IEA, EUROSTAT or

World Bank's online databases concentrate either on electricity market values (prices, concentration of the market, level of generation and energy mix, import and export flows) or, sometimes, on daily (even hourly) electricity flows among countries. Data on physical aspects of the grid are partially available from some specific institutions: the Union for the co-ordination of transmission of electricity (UCTE), the association of the transmission operators of 24 countries of the continental Europe, including both western and eastern countries[1]; Nordel, which operates in the Scandinavian countries[2]; European Transmission System Operators (ETSO, since December 2008 ENTSO) where the previous associations cooperate with operators of other countries[3].

Data for this work have been collected mainly from UCTE archive, and subsequently re-organized in an appropriate dataset. The availability of these data and the political relevance of the represented countries justify the decision to concentrate this research only on most of the EU countries and their neighbours, ignoring the USA, Japan or other OECD members. At the same time, one of the aspects of originality of this work consists of the collection of data on the physical status of TX and ICX and their availability to analyze and to assess what has happened in the UCTE countries between 2000 and 2006. The selected range of years, from 2000 to 2006, guarantees that for many countries the time window embraces the period before and after unbundling implementation and it takes into account also the different steps of unbundling legislation. The annual European Commission's Communications on the Prospects for the internal gas and electricity market (or Benchmarking Reports on the implementation of the internal gas and electricity market), since 2001, have been providing periodic reviews of the levels of implemented unbundling in the EU countries; for the extra-EU information have been collected by the national laws or previous analyses. The same source has been used to identify concentration of the market.

4.3. General overview of the sample

A database has been designed to include 14 countries[4] from UCTE for the TX network and 28 ICX[5] among UCTE members and between UCTE and non-UCTE countries, during the period 2000-2006.

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[1] Austria, Bosnia Herzegovina, Belgium, Bulgaria, Switzerland, Czech Republic, Germany, Denmark West, Spain, France, Greece, Croatia, Hungary, Italy, Luxembourg, Montenegro, FYROM, the Netherlands, Poland, Portugal, Romania, Serbia, Slovenia, Slovak Republic.

[2] Denmark, Finland, Iceland, Norway and Sweden.

[3] UCTE and Nordel Members plus Cyprus, Estonia, Latvia, Lithuania, Ireland, the United Kingdom.

[4] Austria, Belgium, Switzerland, Czech Republic, Germany, Spain, France, Hungary, Italy, the Netherlands, Poland, Portugal, Slovenia and Slovakia

[5] Austria – Switzerland, 1; Austria - Czech Republic, 2; Austria – Germany, 3; Austria – Italy, 4; Austria – Hungary, 5; Austria – Slovenia, 6; Belgium – France, 7; Belgium – the Netherlands, 8; Switzerland – Germany, 9; Switzerland – France, 10; Switzerland –Italy, 11; Czech Republic – Germany, 12; Czech Republic –Poland, 13; Czech Republic – Slovakia, 14; Germany – Denmark East, 15; Germany – Denmark West, 16; Germany –France, 17; Germany - the Netherlands, 18; Germany – Poland, 19; Germany – Sweden, 20; Spain – France, 21; Spain – Portugal, 22; France –

For each country-year pair, physical indicators have been evaluated not in their absolute value, but in their annual growth rate; quality indicators, on the contrary, have been evaluated in their absolute value.

4.3.1. Transmission system data

A general overview of the database concerning TX can be useful before introducing the statistical analysis. First of all, looking at the length of the grid (fig.1), it appears clearly the relevant dimension of TX network in France, Germany, Spain, but also in Italy and Poland.

Between 2000 and 2006, everywhere the dimension of the grid has not considerably changed: as figure 1 shows, annual increases and decreases are almost negligible with the exceptions of Germany and Spain. Both of them have been characterized by an increase of the 380kV network but in Germany the decrease of the 220kV network has negatively affected the net effect. Considering the aggregated data, between the minimum in 2004 and the maximum in 2006 there are no substantial variations. Some essential statistics on the TX grid capacity variation have been reported in the table 4: these data confirm that variations have been quite few and of low impact, as mean and medians clearly show, in particular way for the length grid. Transformers show a wider range between maximum and minimum, due probably to the shift towards a stronger 380kV network.

In relation to qualitative performance of the grid (table 5), more comments can be suggested. First of all, it should be said that these three variables, although interconnected, are not correlated, because each case of disturbance can have different duration and imply different levels of ENS. Secondly, as emerged in the tables, while capacity seems not to have changed substantially, unplanned disturbances in the TX grid occurred with high frequency and involved the most part of the sample, but Austria, Belgium and Slovenia. At the same time, it should be said that standard deviations confirm a high variability among countries, not only for the number of unplanned disturbances, but also, and mainly, for the duration they take and the ENS they imply.

4.3.2. ICX systems data

Differently from the TX-dataset, in general aggregated ICX capacity shows a positive trend of growth, even if, as shown in the tables 6 and 7, due, presumably, to the increased demand of energy which national markets are no longer able to face without relying on higher quantity of imported electricity.

Qualitative performance of the system of ICX show a substantial difference between planned and unplanned disturbances: the former show a high mean and median and the range of values is quite wide, albeit their positive skew; finally higher duration of these disturbances seems to be more

United Kingdom, 23; France – Italy, 24; Italy – Slovenia, 25; Hungary – Slovakia, 26; Poland – Sweden, 27; Poland – Slovakia, 28.

likely linked with higher capacity. Unplanned disturbances are not frequent and their maximum is however lower than the mean of planned disturbances. Median is 0 and the low variance reveals a positive performance of the ICX networks.

In conclusion, this general overview seems to confirm the problems of under-investments the European Commission have been complaining about for the last years. In a context of increasing demand and supply of energy, infrastructures become more and more important for the sustainability of the energy system. Debating on the effective role of unbundling, as promoted and suggested by the EU, cannot forget that, as just said, unbundling, although functional and legal, has been widely introduced so far; nevertheless, while concentration of the market do not decrease, essential physical and qualitative aspects of the grid do not show important growth rates.

4.4. Statistical methodology

In general terms, the empirical analysis compares a group of observations characterized by a specific level of unbundling with the counterfactual case (all the other observations) for each subsample. Afterwards differences emerging from the comparison of the groups' performances will be analyzed to produce some general findings and, eventually, to explain them. Moreover, median has been selected as the statistic that better allows comparing the two groups for each subsample. Two remarks on this statistical methodology are fundamental. Median tests are not parametric tests, so differences between the two groups' medians are a good indicator to discover an impact of unbundling on quality; it is less clear if it is so powerful for capacity values as well. This is the reason why it has been decided not to focus on one single variable, but a set of them has been chosen. Actually, even if a multivariate analysis could better answer to this topic, this is a first attempt to give a sort of robustness to this topic: many different variables as proxies are an attempt to find an answer to the research question about an effective relationship between unbundling and grid investments. Secondly, time is an important limit of this analysis: only seven years, and often even less for some forms of unbundling and for some variables, are quite few, and this could have affected the general results.

Unbundling for each country-year pair has been distinguished according to the EU Benchmarking Reports. In the first test of TX-dataset, medians of countries implementing unbundling *tout court* (U) have been compared to medians of those countries not implementing any form of unbundling. In the second test, countries where ownership unbundling (OU) has been implemented have been compared to the median of the group of countries where it has not. In the ICX database, the two tests include: firstly, couples of countries where both have implemented at least functional unbundling (BU) vs. the counterfactual case; secondly, both countries with ownership unbundled network (BOU) vs. counterfactual case.

5. **Empirical results**

Main findings from the median tests have been here collected in following tables and analyzed. Few words on the rationale the tables have been set with. At first, results of tests on TX-dataset will be assessed, followed by the analysis of the ICX-dataset. Quality indicators have been distinguished from the capacity indicators and separately analyzed. Some of the selected indicators show no relevant findings; the analysis focuses on main and significant results. At the same time the difference among concentrated and competitive markets did not suggest any specific comment, but that concentration does not change systematically the results of tests on the whole sample.

5.1. TX system: quality

Analyzing quality performances in the whole sample (tables 7-9), it can be argued that medians of indicators for U markets are lower than medians in not unbundled countries, which implies that unbundling, if compared to vertical integration, can be associated to less frequent unplanned disturbances, shorter duration and less ENS. It is noteworthy that this evidence can be argued to be independent from the level of concentration of the wholesale markets, as emerged looking at both concentrated and competitive markets (only exception for ENS in U competitive markets). Positive values for quality indicators seem to suggest that unbundling guarantees more incentives to safeguard quality performance of the grid. On the contrary, different findings emerge from the analysis of the OU markets. First of all, as already pointed out, the sample is unbalanced: there is only one ownership-unbundled system among the 21 competitive markets of the sample. Surprisingly, the result is even twisted if related to our hypotheses. OU is associated to worse TX network quality, if compared to not ownership unbundled markets: all the three quality indicators show a higher median value in case of OU. OU, supposed to offer more incentives to improve performances, in fact seems to determine a distortion: not only medians but also means confirm these results.

5.2. TX system: capacity

Comparison of medians of capacity indicators, is characterized by few differences. Furthermore, most of the medians are equal to 0; it confirms the low growth of the grid, as described in the previous sections. Differences emerge in the annual growth rate of the total grid length (table 10): in general, not unbundled markets show a negative median, lower than the U markets. On the contrary, OU markets show a positive median, higher than their counterfactuals' medians, equal to 0. It is a first sign which allows identifying a positive relationship between unbundling and grid capacity growth. This relationship is confirmed in the concentrated OU markets only for the annual growth rate of the grid total length. No other relevant values emerge.

5.3. TX system: final assessment

On the base of the research hypotheses, results have been summarized so as to offer some answers to these questions and a conclusive assessment concerning the TX system. From the analysis, ownership unbundling seems to be related to grid investments in capacity (good statistical significance), on the contrary the system of network and transformers does not show relevant growth. Twisted values, by the way, in ownership unbundled markets' quality indicators show that some problems (e.g. bottlenecks) still remain. On the contrary, U markets have positive performances: their medians are constantly higher than their counterfactual cases. Unbundling *tout court* seems to provide the sufficient incentives to investments in quality and capacity.

5.4. ICX system: quality

In general, it should be said that tests on ICX-dataset provide quite few information, because medians are mainly equal to 0 and the duration of planned disturbances is the only indicator which shows most of the differences. Hence, starting from quality, tests on planned disturbances of the whole sample (table 11) confirm findings on quality in the TX network. In particular, the group of BU countries shows a lower median than their counterfactual. Unbundling in general does not provide enough incentives as it happened for TX-dataset: a stronger separation, at least legal according to the ICX-dataset, guarantees those incentives to invest in ICX and, probably, to strengthen competition with foreign players.

5.5. **ICX system: capacity**

Focusing on capacity (table 13), in the cases of BOU, medians confirm a twisted result, with a better performance in the annual growth rate of capacity but, as said before, a worse quality due to longer planned disturbances. It can be explained as the same phenomenon occurring in the TX systems, where increasing physical capacity does not imply any improvement of the sustainability of the system. Interventions on the capacity of tie-lines have not been accompanied by an adequate level of quality of the grid.

5.6. **ICX system: final assessment**

It could be argued that unbundling is not *always* related to an increase of grid investments (hence to a pro-competitive impact), but it depends on the circumstances. Two *caveats* are important to be fixed: 'planned disturbances' could be an ambiguous indicator of quality, because it could show both the interventions due to network obsolescence, and the interventions to upload network. In the former case, the higher is its value the worse is the performance of the network. This is the interpretation that, based on engineering empirical evidence, has been assumed: thus, it confirms previous comments, but, anyway, more country-specific analysis is required. Secondly, the sample has been divided on the base of the concentration of both the countries of each ICX; however, unbundling impacts on ICX between a concentrated market and a competitive one can be different from the impacts between two competitive markets: the low number of observations in this latter case, only 11 observations, has not let any further statistically significant analysis. In few words, what happens in a tie-line depends not only on the policy of each country but also on the interactions between them.

6. Conclusion and policy implications

This work aims to offer some preliminary findings on the impact unbundling policies had in the UCTE countries between 2000 and 2006. From the debate among scholars on the relation between unbundling and grid investments and development, empirical results have been obtained; they emerge from statistical analysis.

First of all, answering to the research question on whether unbundling does matter and to what extent, it should be said that ownership unbundling, the core of the third package of reforms by the EC, does not show an incontrovertible evidence of better quality and capacity expansion as assumed in the hypotheses. The developments in quality and capacity emerging in this analysis show, above all, an enlargement of the grid at the peripheries, but not a substantial enforcement of the grid, in order to guarantee the sustainability of the electricity flows. On the contrary, ownership unbundling not only does show no improvement of investments in the network, but also a lack of quality emerges, so that these twisted results move severe doubts on the recent EU policies. Another hypothesis has not been confirmed: albeit a stronger positive relationship was expected at least in concentrated markets between unbundling and grid investments, on the contrary, it is in this very case that twisted results emerge. On the other hand, a more positive relationship concerns already competitive markets. These findings could be justified by scholars' arguments underlining the prevalence of costs of unbundling. It seems useful to consider the possibility of other reasons which, even in case of unbundling, have not let the development of the grid, and the increase of competition. One of the reasons could be the role of Governments: the presence of a wide public ownership, both in the incumbents and in the transcos (as in French EDF and RTE), do not encourage new competitors, do strengthen the interest in few ICX and low capacity, which could let foreign suppliers to enter the market, but, at the same time, could guarantee a good service. Thus, geopolitics, as well as lobbying from the incumbents, could have an important role in influencing policies and in explaining these results.

Secondly, strictly related to the previous comment, there is an urgent need of more studies on this topic: in particular a multivariate analysis could put in evidence the relation between aspects of both the economics of TX policies and the politics of energy markets.

Thirdly: in order to widen studies on TX systems, more data should be made available by international institutions and operators as well. The current gap, this work had to face, makes very hard to collect harmonized data: at the same time, there are many institutions which are related to TX and ICX systems, both international and national, both regulatory authorities and associations of operators. One of the reasons could be the low importance given to the TX system, if related to generation and retail: nevertheless, as said at the beginning of this work, TX network and ICX have a more and more decisive role to make the entire system sustainable and to pursue the goals of competitiveness, environmental sustainability and supply security.

A final remark on the policy implications for the EU: first of all, it should be noted how unbundling is an invasive measure, requiring time to be implemented and to evaluate its effective impact. As emerged, OU cannot be considered as a *panacea*, because positive results can be pointed out also in not unbundled systems. On the contrary OU could be related to problematic consequences in the medium/short run, at least on quality; unbundling in general better safeguards the grid. A first implication concerns the way policies are suggested and implemented: if OU is adopted, results should be assumed to emerge in the long run, not before, and, possibly, introduces some corrections to avoid distortions above all on quality. Furthermore, the right policy to be suggested is not a single and general policy for all the MS: it could be probably more impacting an approach where a single and general goal (or set of goals) is identified by the EU and checked by the Commission or by an Agency, and, according to the fulfilment of the goal(s), each model of electric system can be assessed. An approach encouraging regional coordinated programs, as the EU is beginning to practice, could be a more effective step.

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Table 1: TX capacity and quality indicators; source of indicators: UCTE statistical yearbooks 2000-2006

Name	Definition	Time
Length 220kV grid	Length of the 220kV grid [Km]	00-06
Length 380kV grid	Length of the 380kV grid [Km]	00-06
Total length grid	Sum of the length of the 220kV and the 380kV grid [Km]	00-06
Capacity Transformers 380/400 – 220	Capacity of transformers in the network from 380/400kV to 220kV [GVA]	00-06
Capacity Transformers 220 - < 220	Capacity of transformers in the network from 220kV to less than 220kV [GVA]	00-06
Capacity Transformers 380/400 - < 220	Capacity of transformers in the network from 380/400kV to less than 220kV [GVA]	00-06
Number Transformers 380/400 - 220	Number of transformers in the network from 380/400kV to 220kV [GVA]	00-06
Number Transformers 220 - < 220	Number of transformers in the network from 220kV to less than 220kV [GVA]	00-06
Number Transformers 380/400 - < 220	Number of transformers in the network from 380/400kV to less than 220kV [GVA]	00-06
Number of unplanned disturbances	Number of disturbances due to a) overload or failure in the transmission network (UCTE code 2002-2003: R3-R6); b) overload or false operation or failure in protection device or other elements (UCTE code 2004-2006: R4-R6)	02-06
Duration of unplanned disturbances	Restoration time for unplanned disturbances in minutes	02-06
Energy Not Supplied (ENS) in unplanned disturbances	Estimated amount of energy which would have been supplied if the unplanned disturbance (defined as above) did not occur; measured in MWh	02-06

Table 2: ICX capacity and quality indicators

Name	Definition	Time
Conventional Thermal Capacity	Sum of the thermal load capability of cross-frontier tie-lines of each interconnection, calculated on parameters standardised by the UCTE based on specific ambient temperature, wind velocity and voltage; measured [MVA]	00-06
Number of Circuits	Number of cross-frontier tie-lines for each interconnection	00-06
Duration of planned disturbance	Time of unavailability of cross-frontier tie-lines due to maintenance, repair or new construction (UCTE code 2002-2003: R1-R2; UCTE code 2004-2006: R1-R3)	02-06
Duration of unplanned disturbances	Time of unavailability of cross-frontier tie-lines due to a) overload or failure in the transmission network (UCTE code 2002-2003: R3-R6); b) overload or false operation or failure in protection device or other elements (UCTE code 2004-2006: R4-R6)	02-06

Table 3: Regulatory indicators

Name	Definition	Time	Source
TX Unbundling	Level of Unbundling of Transmission Network distinguished among: - Ownership unbundling (OU) - Legal unbundling (LU) - Functional or Accounting unbundling (FU) - No unbundling	00-06	European Commission's Benchmarking Reports on the implementation of the internal electricity and gas market; Swiss Department for Energy; National Authorities
Concentration of the market	Concentration of the wholesale market. According to usual parameters, markets are supposed to be concentrated (CONC=1) whether: - The largest company's market share (C1) is higher than 33%; or - The sum of the three largest companies' market shares (C3) is higher than 50%; or - The Herfindahl-Hirschman index	00-06	EUROSTAT; European Commission's Benchmarking Reports on the implementation of the internal electricity and gas market; National Authorities

	(HHI), defined as the sum of the squares of the market shares, in percent, of all firms in the market, is higher than 1800

Table 4: Statistics on annual growth rate of physical indicators in TX-dataset

	Total length grid (Annual growth rate)	Number of Transformers (Annual growth rate)
Time	2001-2006	2001-2006
Obs.	84	84
Mean	0.005414	-0.007212
Median	0	0
Maximum	0.131755	0.352941
Minimum	-0.081009	-0.783871
Std. Deviation	0.026126	0.114034
Skewness	1.011371	-3.827977
Kurtosis	10.46348	28.41616

Table 5: Statistics of quality indicators in TX-dataset: unplanned disturbances

	Number	Duration [minutes]	ENS [MWh]
Time	2002-2006	2002-2006	2002-2006
Obs.	65	65	65
Mean	2.476923	1240.954	3791.108
Median	1	15	20
Maximum	22	39485	180099
Minimum	0	0	0
Std. Deviation	3.996513	5262.922	22515.53
Skewness	2.528374	6.278734	7.573142
Kurtosis	10.73603	44.74125	59.68025

Table 6: Statistics on indicators in ICX-dataset

	Conventional Thermal Capacity (Annual growth rate)	Number of Circuits (Annual growth rate)	Duration of planned disturb. [minutes]	Duration of unplanned disturb. [minutes]
Time	2001-2006	2001-2006	2002-2006	2002-2006
Obs.	164	166	140	140
Mean	0.023529	0.007531	53625.88	440.7429
Median	0	0	37880	0
Maximum	0.892449	0.333333	245673	10288
Minimum	-0.227131	-0.2	0	0
Std. Deviation	0.133886	0.057018	52031.31	1465.747
Skewness	4.276916	3.42723	1.399926	4.569018
Kurtosis	25.10064	21.12719	4.629078	25.211

Table 7: quality in TX network 2002-2006; Number of unplanned disturbances

	Obs.	Median [number]	Wilcoxon/Mann-Whitney test: p-value
OU markets	*22*	1	0.95
Counterfactual	*41*	0	
U markets	*54*	0.5	0.10*
No unbundling	*9*	3	
All sample	*63*	1	

Table 8: quality in TX network 2002-2006; duration of unplanned disturbances

	obs.	Median [min]	Wilcoxon/Mann-Whitney test: p-value
OU markets	*24*	31	0.11

Counterfactual	*37*	0	
U markets	*53*	0	0.27
No unbundling	*8*	90	
All sample	*61*	10	

Table 9: quality in TX network 2002-2006; ENS in unplanned disturbances

	obs.	**Median [MWh]**	**Wilcoxon/Mann-Whitney test: p-value**
OU markets	*24*	28.5	0.27
Counterfactual	*39*	0	
U markets	*55*	13	0.30
No unbundling	*8*	160	
All sample	*63*	16	

Table 10: capacity in TX network 2001-2006; total grid length annual growth

	obs.	**Median (growth rate)**	**Wilcoxon/Mann-Whitney test: p-value**
OU markets	*27*	0.0000603	0.03**
Counterfactual	*57*	0	
U markets	*70*	0	0.05**
No unbundling	*14*	-0.0000947	
All sample	*84*	0	

Table 11: quality in ICX network 2002-2006; duration of planned disturbances

	obs.	**Median [min]**	**Wilcoxon/Mann-Whitney test: p-value**
BOU markets	*9*	89654	0.007***
Counterfactual	*124*	29975.5	
BU markets	*98*	32980	0.66
No unbundling	*35*	33942	
All	*133*	33134	

Table 12: quality in ICX network 2002-2006; duration of unplanned disturbances

	obs.	**Median [min]**	**Wilcoxon/Mann-Whitney test: p-value**
BOU markets	*9*	0	0.43
Counterfactual	*126*	0	
BU markets	*100*	0	0.04**
No unbundling	*35*	0	
All	*135*	0	

Table 13: capacity in ICX network 2001-2006; conventional thermal capacity annual growth rate

	obs.	**Median [growth rate]**	**Wilcoxon/Mann-Whitney test: p-value**
BOU markets	*10*	0.020947	0.09*
Counterfactual	*154*	0	
BU markets	*113*	0	0.96
No unbundling	*51*	0	
All	*164*	0	

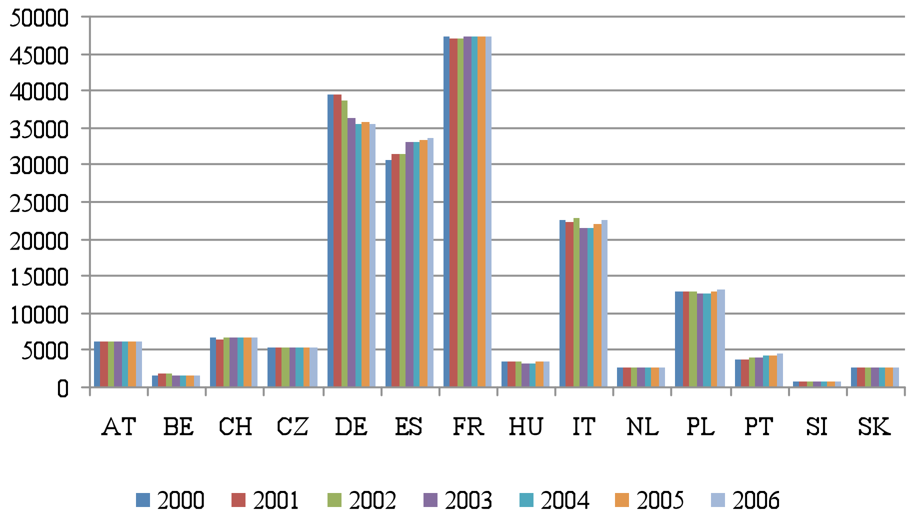

Figure 1: Grid length of the network between 2000 and 2006. UCTE Statistical Yearbooks

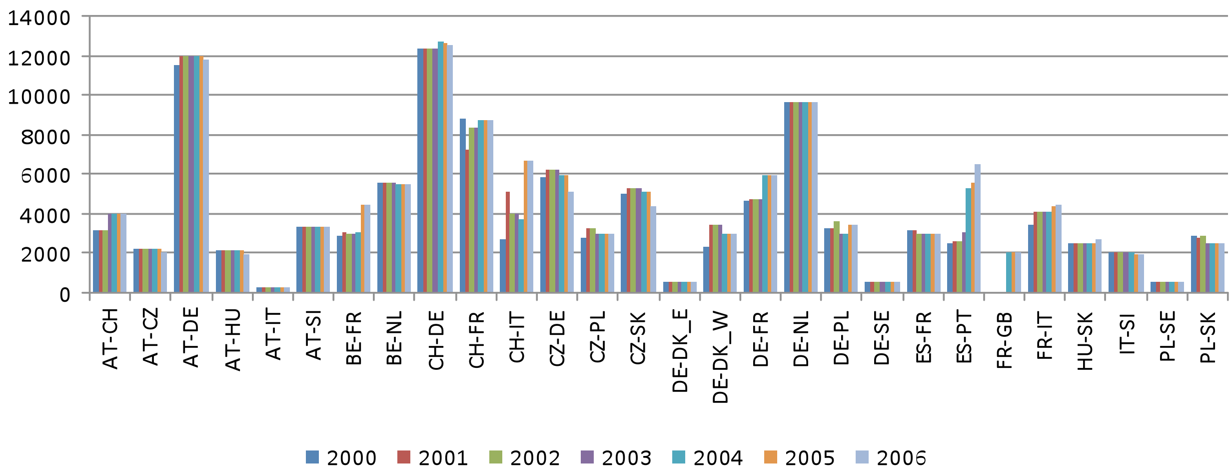

Figure 2: Conventional thermal capacity of ICX networks in ICX-dataset