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Interconnections in the Spanish and Portuguese Electricity Markets and the Effect on Market Power

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by

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Abstract

This study analyses the effects on the electricity markets in Spain and Portugal of increasing the interconnection capacity between both markets. Using the data concerning the hourly bids made every day by the electricity generating companies a simulation is performed. The effect on prices and market power – measured by the residual supply index of the largest market players – are been analysed using the results from the model.

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1. Introduction

The setting up of an internal European electricity market started at the end of the 1980s. Using a process of liberalisation the European Union (EU) aims to reach a final stage in which any customers anywhere in the European Union will be able to initiate competition between all suppliers prepared to serve them. By putting up more interconnections the electricity markets should evolve from national markets to regional ones. There are several reasons why larger markets should be preferred. The most important advantages of a more interconnected European energy market are an increase in security of supply, a reduction of the total reserves needed to maintain a sufficient level of system performance and lower energy prices due to a higher level of competition.

In this paper the focus lies on the effect of interconnections on market and thus on the energy prices. The study is performed for the electricity markets of Spain and Portugal. The process of liberalisation in these markets has been very slow, but the launch last year (July 2007) of the Iberian Electricity Market (MIBEL) should speed up the integration within these markets and with the rest of Europe.

Electricity in Spain and Portugal is characterised by very similar sectorial segments (residential: 25%, industry: 40%, services: 30%, agriculture and transportation: 5%) and annual average growth rates which are a lot higher than the European average (during the ten-year period 1990-1999: 4.9% in Portugal, 3.9% in Spain and 1.8% in the

European Union EU15). However the per capita consumption values are lower in comparison to the European average (3677 kWh in Portugal, 4694 kWh in Spain and 5681 kWh in the European Union)[2].

The 'Mercado Ibérico de la Electricidad' (MIBEL) is the result of the integration of the Spanish and Portuguese electricity markets. It is thought to be an important advance in the integration of the economies in both countries. The Iberian electricity market has one of the highest forecast growth rates in Europe and the potential for growth in trading in MIBEL is considerable. This is leading to an increasing interest in the region. However, the level of competition in the Iberian market remains quite low; the Spanish electricity market continues to be severely dominated by the duopoly of 'Endesa' and 'Iberdrola', accounting for 70% of the supply, and in Portugal 'Energias de Portugal (EDP)' controls as much as 90% of the market.

MIBEL currently has two different market operators: OMEL – the spot market – which includes daily and intra-daily markets and is managed from Madrid; and OMIP – the forward market – managed from Lisbon. OMEL and OMIP will eventually be merged into a single market operator (OMI).

The electricity producing companies make hourly bids every day to sell their electricity through the wholesale market, organised by the 'Operador del Marcado Eléctrico' (OMEL). For each station up to 25 bids – quantity-price pairs – are allowed. The system price is determined by crossing the supply bids with the demands realized by the end-suppliers, distributors and some large consumers.

'Red Eléctrica de España' (REE) is the operator of the transportation network and guarantees the proper functioning of the system and the technical maintenance of the network.

The current interlinking capacity installed between Portugal and Spain is about 1600 MW (megawatts), or 15% of peak power consumption requirement, and the target is for this to be stepped up to 27% by 2010[3]. The limited interconnection capacity

[2] The Iberian Electricity Market – Organisational Model, Comisión Nacional de Energía (CNE) – Entidade Reguladora do Sector Eléctrico (ERSE), March 2002.

[3] Essent Trading – Iberian Electricity Market, May 2008, http://www.essenttrading.com/mibelapril2008;jsessionid=CE3505D8D44D2353F9B8EFEB4602406E.

between the two countries holds back the opportunity of a single Iberian electricity market.

The paper is organised as follows. Section 2 mentions some literature work related to the topic of this study.
Section 3 describes which data are been used in this study and from which sources they were obtained. Some economic parameters are been calculated to have a general idea about the current situation concerning market power in Spain and Portugal. Additionally a number of descriptive statistics are been performed on the data that will be used in the study.
Section 4 explains which type of model is been used to simulate the electricity markets of interest and shows in detail how the model is implemented. It says which data is read in, how the calculations are performed and how the output is visualised. Also some extra features of the model that are not used in this study are commented.
Section 5 talks about which simulations have been done and how the output can be interpreted. It also notes which the limitations of the obtained results are and how this affects the interpretation of the results.
Section 6 summarizes the final conclusions of the study and the implications on future policies about interconnections in the studied electricity markets.
At last the used references are been summarized in section 7.

2. Literature Review

Hobbs et al. (2005) study the effect on competition of eliminating trade barriers between two market powers. Using a Cournot model that accounts for transmission pricing, shows how a more efficient use of intercountry transmission is achieved which is good for competition. However, if the dominant firm in the market behaves strategically from a price-taking behavior, then losses may happen. Regulatory authorities must be vigilant on firm behavior.
Borenstein et al. (2000) study the impact of transmission capacity on competition. They use a two-country model with a local monopolistic firm to show that a small size interconnection is enough for the two firms to become Cournot players. They simulate the model using 1998 data from the California deregulated market. They conclude that

an interconnection of about 20 percent of the installed capacity in the smaller area is enough to obtain a single competitive price (provided firms do not collude).
Moselle et al. (2006) analyze the Dutch market for electricity. They estimate that interconnections with neighboring countries, Belgium and Germany, should be at least 30 percent of total installed capacity.
Malaguzzi (2008) finds that for the Irish case, an interconnection of about 35 percent of the installed capacity is enough to obtain a single competitive price in the islands.

3. The Data

The data used to perform the calculations and simulations in this study are obtained from the website of the 'Operador del Mercado Ibérico de Energía (OMEL)' (www.omel.es)[4].

We use data associated with the following information:

- Market shares of the firms in the sector, both for the production and purchase side of electricity.
- Hourly bids done by every available generating station in the pool, quantity and price at which the offer is made.
- Daily market hourly price.
- Total capacity of each station.
- Technology type of each station.
- The share of ownership of each station for the biggest firms.
- Capacity of interconnections with neighbouring countries.

Data is obtained for both Spain and Portugal. We consider the period from the 1st to the 15th of July of 2007. Therefore we have 360 hour-observations.

To have an idea of the current situation concerning market power in the electricity markets of Spain and Portugal the Herfindahl index is calculated for this month. The

[4] Operador del Mercado Ibérico de Energía (OMEL) – www.omel.es , 2008

Herfindahl index is a measure for market concentration. It takes into account the relative size and distribution of the firms in a market. The index is calculated as the sum of the squares of the market shares of each individual firm:

$H = \sum_{i=1}^{N} s_i^2$, where s_i is the market share of firm i in the market and N the number of firms in the sector.

As can be seen from the formula the Herfindahl index can range from zero to one moving from a very large amount of very small firms to a single monopolistic producer. It increases both as the number of firms in the market decreases and as the disproportion in size between those firms increases. An increase in the Herfindahl index generally indicates a gain of market power and a decrease in competition, whereas a decrease implies the contrary.

Calculating the Herfindahl index one has to take into account that some big players like 'Endesa', 'Iberdrola', 'Energías de Portugal'… have separated some of their activities in smaller firms. Still the final owner of these companies is the same, so before calculating the Herfindalh index the data for these firms have to be aggregated. Additionally in some cases these big firms own a share of smaller firms, which obviously also have to be included. If we would skip these two steps we would obtain a Herfindalh index which indicates a lower market concentration, because we would consider those smaller firms as independent firms.

Table 1 below summarizes the calculated Herfindahl indexes for Spain, Portugal and the Iberian Peninsula, for July 2007. These results are obtained using the Market shares of the PVD market ('Programa Viable Diario') which includes some corrections as opposed to the PBC market data ('Programa Básico de Casación') which doesn't include these adaptations.

	Iberian Peninsula	Spain	Portugal
Production	1323,30	1575,60	5991,19
Purchase	2498,07	3025,25	8466,65

Table 1 – Herfindahl index for July 2007

As stated before, the Herfindahl index is a general measure for market concentration, a value higher than 1800 denotes a highly concentrated market, where abuse of market

power is considered more likely, whereas a value between 1000 and 1800 indicates moderate concentration, and a value below 1000 stands for an un-concentrated market[5]. As can be seen from the results in table 1, the electricity market of Portugal is extremely concentrated. This is mainly caused by the big (around 90%) market share of 'Energías de Portugal (EDP)' in the Portuguese market. Nevertheless also the Spanish electricity market is considerably concentrated. It seems that the production markets are less concentrated than the purchase markets. When considering the whole market of the Iberian Peninsula as one market – supposing the interconnections between Spain and Portugal are never completely used up – we observe a less concentrated market.

Table 2 summarizes the current situation concerning the interconnections for Spain[6]. From this table it can be seen that the interconnection with Portugal is the most important one, therefore we will focus on this interconnection in this study.

Connection	Minimum	Maximum
France - Spain	500	1000
Spain - France	0	300
Portugal - Spain	1300	1700
Spain - Portugal	700	1400
Morocco - Spain	400	600
Spain - Morocco	400	700

Table 2 – Capacity of commercial interchange (MW)

Using data July 2007 we calculate the mean of the electricity prices for Spain and Portugal when there is congestion of the interconnection capacity. When there is no congestion – and thus the prices are equal – the mean of the electricity prices is calculated for the whole Iberian Pensinsula ('Mibel'). These results are summarized in Table 3. It is apparent that the price in Portugal is substantially higher than in Spain. The 'Mibel' electricity price lies between the prices of both countries. Some possible explanations are:

- The extra demand of Portugal that is covered by the Spanish market is large enough to increase the price in Spain substantially.

[5] Wikipedia, the free encyclopedia – Herfindahl index, http://en.wikipedia.org/wiki/Herfindahl_index, 2008.
[6] Red Eléctrica de España (REE) – International Connections, 2008 http://www.ree.es/ingles/operacion/capacidades.asp

- The prices in Portugal and Spain are equal when the price is high in Spain, and therefore the interconnection is not saturated.
- A combination of the above.

	Spain	Portugal	Mibel
Peak hour (23:00)	3,908 (19 obs.)	4,948 (19 obs.)	4,643 (12 obs.)
Off-peak hour (10:00)	3,829 (18 obs.)	4,832 (18 obs.)	4,247 (13 obs.)

Table 3 – Mean of electricity prices in Spain and Portugal with congestion of the interconnection and for 'Mibel' without congestion (eurocent/kWh)

In table 4 the percentages per type of produced energy are shown for the period we are studying, from the 1st to the 15th of July 2007. The Iberian Peninsula and Spain both have about a quarter of their total energy produced by coal stations and about a quarter by combined cycle technology. Spain has about one fifth of its energy provided by renewable sources (special regime). Another 16% of the energy in Spain is produced using nuclear technology. The shares of renewable and nuclear energy in the Iberian Peninsula are fully determined by the shares in Spain since Portugal doesn't own any of such installations. In Portugal the shares of coal and combined cycle stations are even bigger than in Spain (33% and 42% respectively). The hydroelectric stations account for the remaining quarter of the energy produced in Portugal.

When looking at the numbers about the total produced energy, one can see that Spain accounts for about almost 90% of the total Iberian electricity market. It is clear that because of difference in market size the Portuguese market will be much more affected by changes in the market structure, and thus by increasing the interconnection capacity.

	Iberian Peninsula	Spain	Portugal
Special Regime to Distribution	17,86	20,10	0,00
Nuclear	14,58	16,41	0,00
International Exchanges	2,81	3,17	0,00
Hydroelectric	11,29	9,66	24,35
Coal	26,97	26,20	33,14
Combined Cycle	25,25	23,13	42,20
Fuel Oil-gas	1,24	1,35	0,31
Total production (in MW) (1 to 15 July 2007)	12.545.302	11.146.818	1.398.488
Percentage of total produced energy	100,00	88,85	11,15

Table 4 – Percentages per type of produced energy and percentage of total produced energy from 1 to 15 July 2007

Table 5 illustrates the installed capacity for both countries and how it is distributed over the different technologies.

	Spain	Portugal
Hydro	16.658	4.582
Nuclear	7.716	0
Coal	11.867	1.776
Fuel/gas	8.758	1.877
Combined Cycle	22.097	2.166
Wind	13.606	0
Rest Special System	10.021	0
Total	**90.723**	**10.401**

Table 5 – Installed capacity in 2007 (in MW) [7] [8]

4. The Model

In order to perform the simulation an optimal dispatch model is been used. This model is based on the models used in the papers about electricity interconnection between Great Britain and Ireland by L. Malaguzzi Valeri[9] and N. McCarthy[10].

Since we are dealing with electricity markets we have to consider electricity as a product. Electricity is a homogenous good because the end product is always the same and it has an inelastic demand since it is a necessary good for households and businesses. These characteristics of electricity give the electricity firms a considerable amount of market power, which is one of the reasons for regulation of the industry.

Another typical property of electricity as a product is that it can not be stored, so real-time dispatch must occur to prevent "blackouts". The market must be cleared in real-time. So, in order to ensure the least expensive outcome it is necessary to make use of the most efficient generators for that particular time of the day.

[7] The Spanish electricity system – Preliminary report 2007, Red Eléctrica de España (REE), www.ree.es, 2007.

[8] Dados Técnicos Electricidade – Valores Provisórios 2007, Redes Energéticas Nacionais (REN), www.ren.pt, 2007.

[9] Malaguzzi Valeri L., Welfare and competition effects of electricity interconnection between Great Britain and Ireland, March 2008.

[10] McCarthy N., Market Size, Market Structure & Market Power in the Irish Electricity Market, ERSI – Working paper No. 168, 2005.

The model simulates the wholesale market of Spain and Portugal. It is a pool system in which each station bids into the market up to 25 price/volume combinations for the same hour one day ahead.

As said before, we use the data regarding the hourly bids of the July 2007, together with data about the total capacity of every generating station, data about the type of each station and data about the demand for every hour.

The model simulates the process that takes place at the pool. The bids for each hour are sorted such that the lowest price is first and the highest price is last. So, bids are ranked according there prices in ascending order.

Next a cumulative capacity vector is been generated. This vector is used to compare with the exogenous demand for that hour. In that way all the bids, and thus stations, necessary to generate electricity can be identified. Next the individual capacity produced for each bid is been calculated.

For every station all of its bids are been summed up to obtain the produced capacity by each station. Because in this particular study we are no interested in the results for each different station, I have disabled this option to reduce calculation time.

The system price is determined by the marginal bid, and is returned by the program.

The model also takes into account which type of technology is been used by each different station. However in this study I do not use this information explicitly it can be used to perform calculations concerning production costs and effects of changes in fuel taxation, subsidies on renewable energy…

At last the program calculates the Residual Supply Indices (RSI_i) for the largest market players. The RSI_i is defined as the ratio of residual supply to demand, for an individual supplier i [11]:

$$RSI_i = \frac{\text{Total Available Supply - Available Supply from Supplier } i}{\text{Demand}}$$

The Residual Supply Index measures the share of electricity demand that can be covered in the absence of this particular player. When the share is large is means that the largest player is not very influential. In order for an electricity system to be

[11] McCarthy N., Market Size, Market Structure & Market Power in the Irish Electricity Market, ERSI – Working paper No. 168, 2005.

considered competitive the RSI_i should be above 1.1 at least 95 percent of the time[12]. In our model we calculate the RSI_i of the following firms: 'Endesa', 'Iberdrola', 'Unión Fenosa', 'Energías de Portugal'. Also the Residual Supply Index is been calculated for the stations for which no information of ownership share was considered, this is denoted by 'Others'.

All these calculations are performed for every hour of the first 15 days of July 2007 and are executed by calling the MATLAB-function 'calculations.m', which has as arguments:

- A matrix 'DATA' containing the information about the bids for that hour in the specific country, information about electricity prices in Spain and Portugal and the technology type, firms shares, and total capacities of each station.
- A vector 'CODOF' which contains a unique code to identify each generating station.
- 'Demand': the demand for that hour in the specific country.
- 'extrademand': the extra demand that is delivered to the other country as a result of increasing interconnection capacity.
- 'price_interconnection' and 'capacity_interconnection': the extra amount of energy offered because of import form the other country, at the other country's electricity price.

In this specific study we are interested in studying the effects of increasing the interconnection capacity between Spain and Portugal. Therefore this process is repeated iteratively for a given amount of extra interconnection capacity. This is performed by the MATLAB-program 'Model.m'. It consists out of the following steps:

- It reads in the data about the demand and the data about each country considered for the specific hour of the particular day. We have two possible cases:
    - When prices in Spain and Portugal differ 'OMEL' supplies separate data for the two countries. In this case we read in the data for each country and perform the calculations for both countries.

[12] Sheffrin A., Predicting Market Power Using the Residual Supply Index, mimeo, Department of Market Analysis, California ISO, 2002.

- When prices in Spain and Portugal are equal 'OMEL' supplies the data in an aggregated form. Now we only read in the aggregated data and perform the calculations considering the entire Iberian Peninsula ('Mibel').

- With these first results the iteration process is started. It consists of a double iteration process.
  - The outer iteration is used to increase – in small steps (50MW) – the portion of available extra interconnection capacity used. This iteration stops when the electricity prices of both countries become quasi equal or when the total available extra interconnection capacity is reached. This is necessarily done in small steps to be sure of approaching the equilibrium. If we would add the whole interconnection in one iteration step we would get stuck in the iteration because each country in turn would become the cheapest one. This would imply infinitely iterating without approaching the solution.
  - The inner iteration performs the calculation of prices and RSI_i's iteratively until prices do not change significantly or become very close to each other.

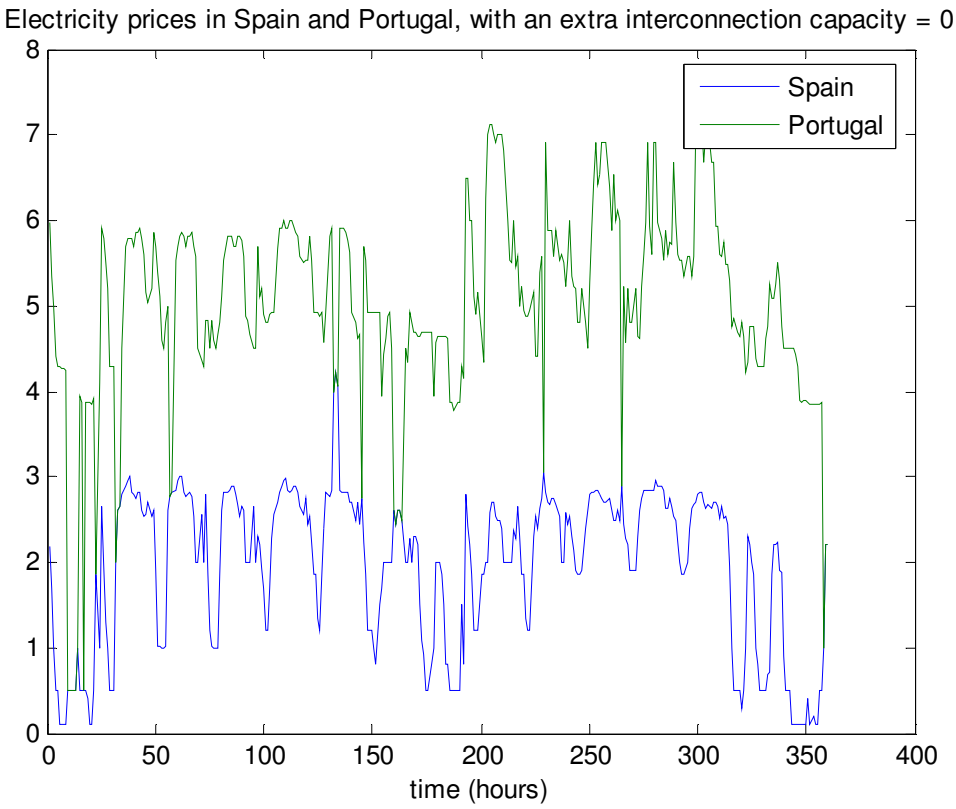
  While running the program displays two counters for the number of iterations, this is used to verify whether the program stagnates in one of the iterations. The stop criteria of the loops can then be adjusted to obtain results.
- The program saves all the calculated values in matrices with dimension $15 \text{ days} \times 24 \text{ hours}$. From these matrices it generates vectors to be able to plot the results.
- At last the results of interest – prices, Residual Supply Indices and interchanged capacities – are been plotted along time.

5. Simulation and results

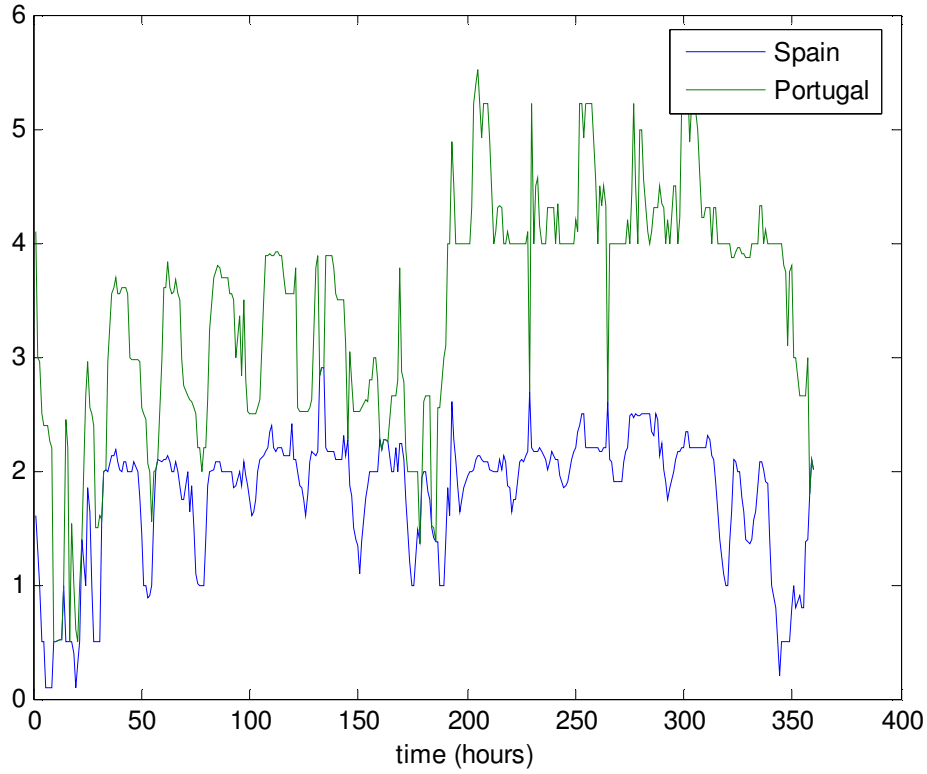
As stated before, in this study we are interested in the effects of increasing the interconnection capacity between Spain and Portugal. In this simulation we abstract from extra interconnections that could be made with the neighbouring countries France

and Morocco. Using the program described above we investigate the effects of increasing the current interconnection capacity of about 1600 MW by an amount of 0 MW, 1500 MW, 3000 MW, 5000 MW and 10000 MW respectively.

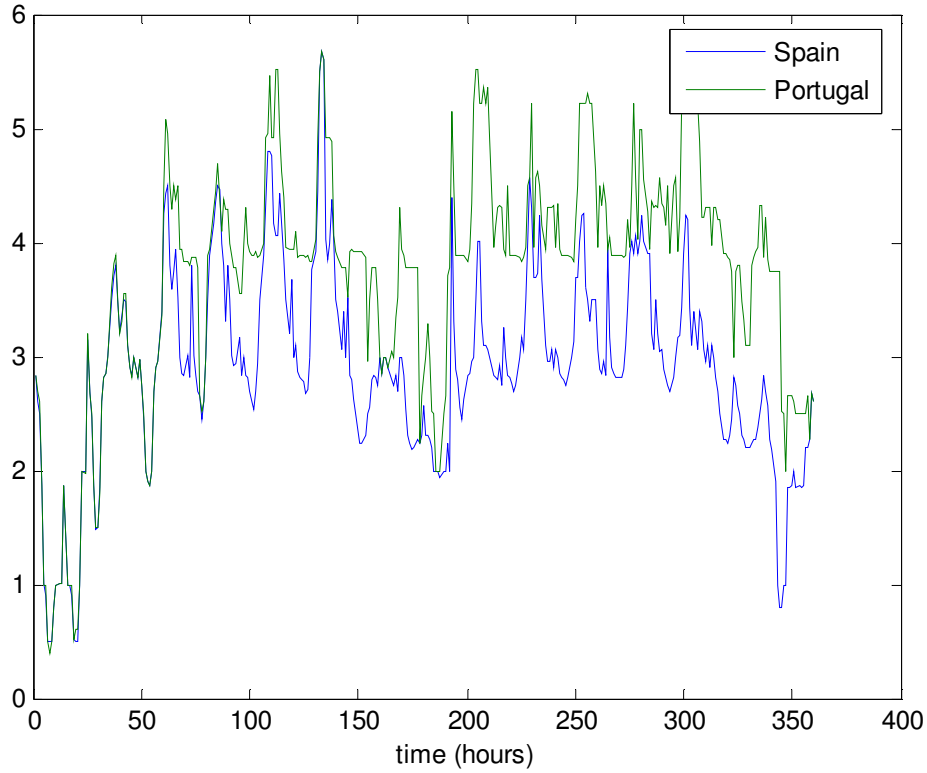
In the following graphs the results from the simulations are been summarized. First, in figures 1 to 5 the impact of increasing the interconnection capacity on the electricity prices in Spain and Portugal is shown.

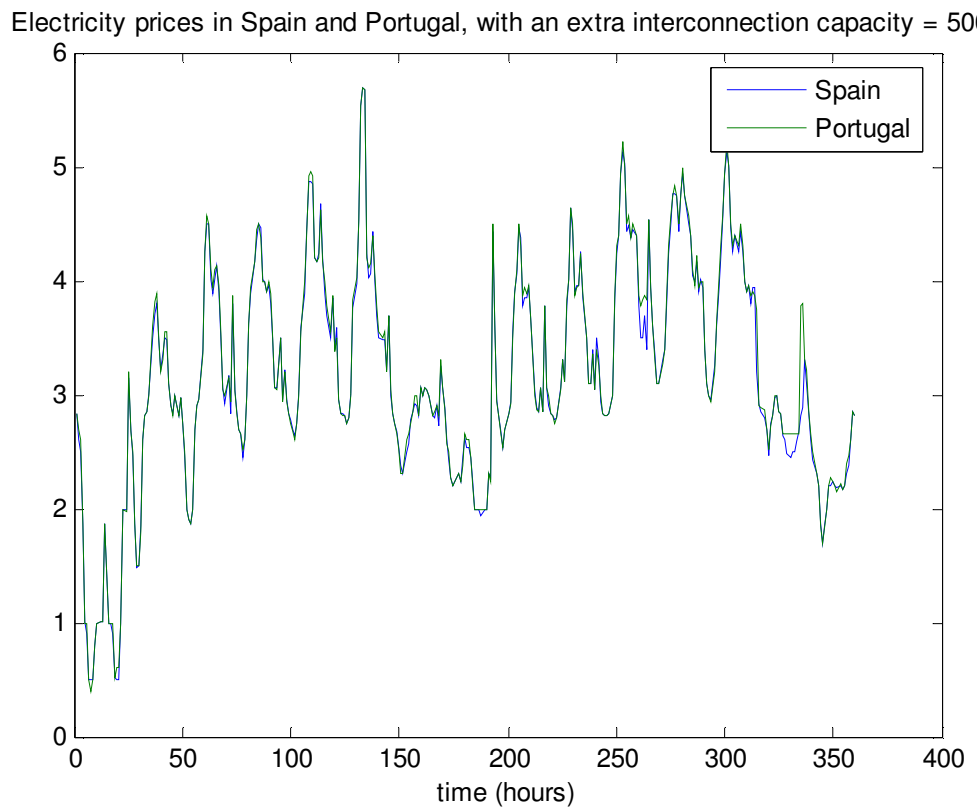


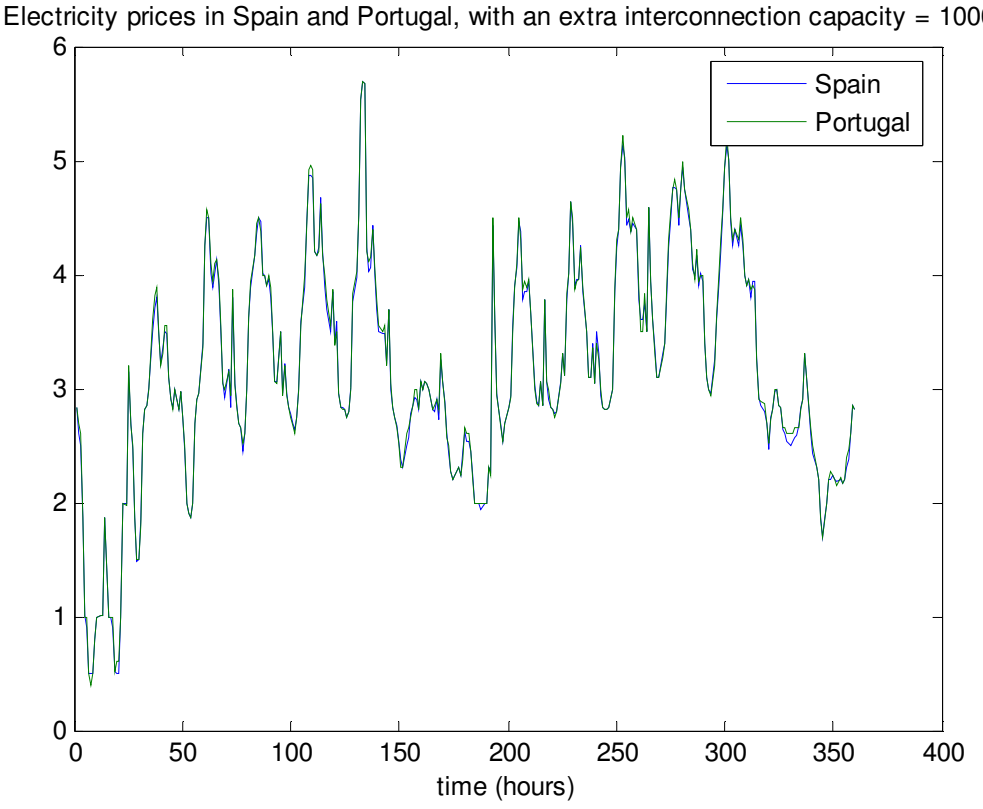
Electricity prices in Spain and Portugal, with an extra interconnection capacity = 1500



Electricity prices in Spain and Portugal, with an extra interconnection capacity = 3000



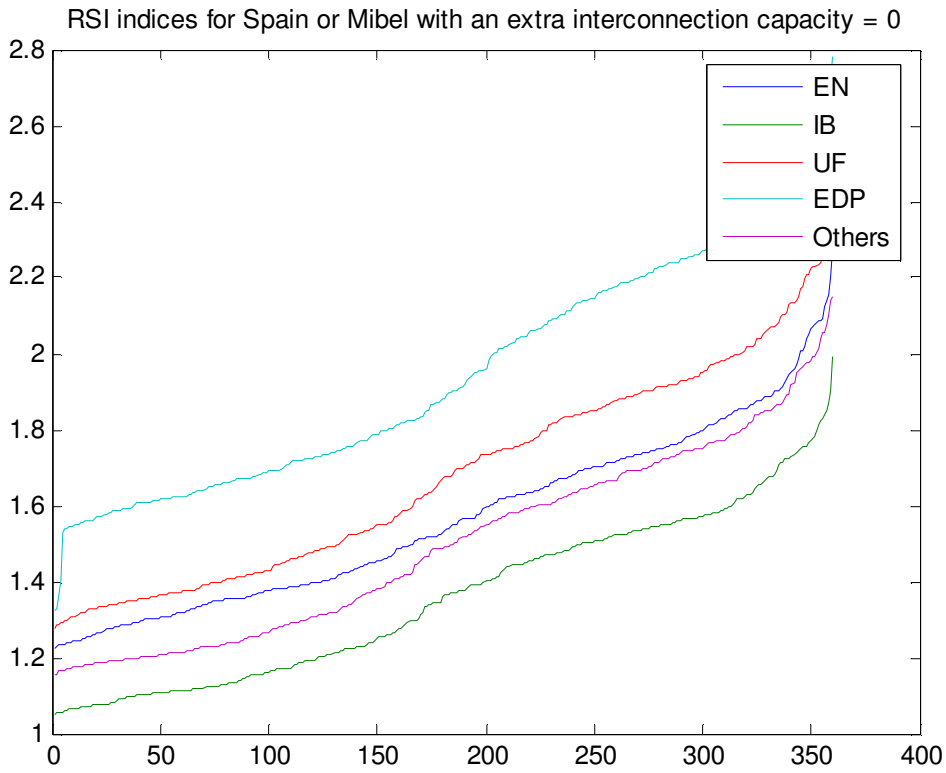


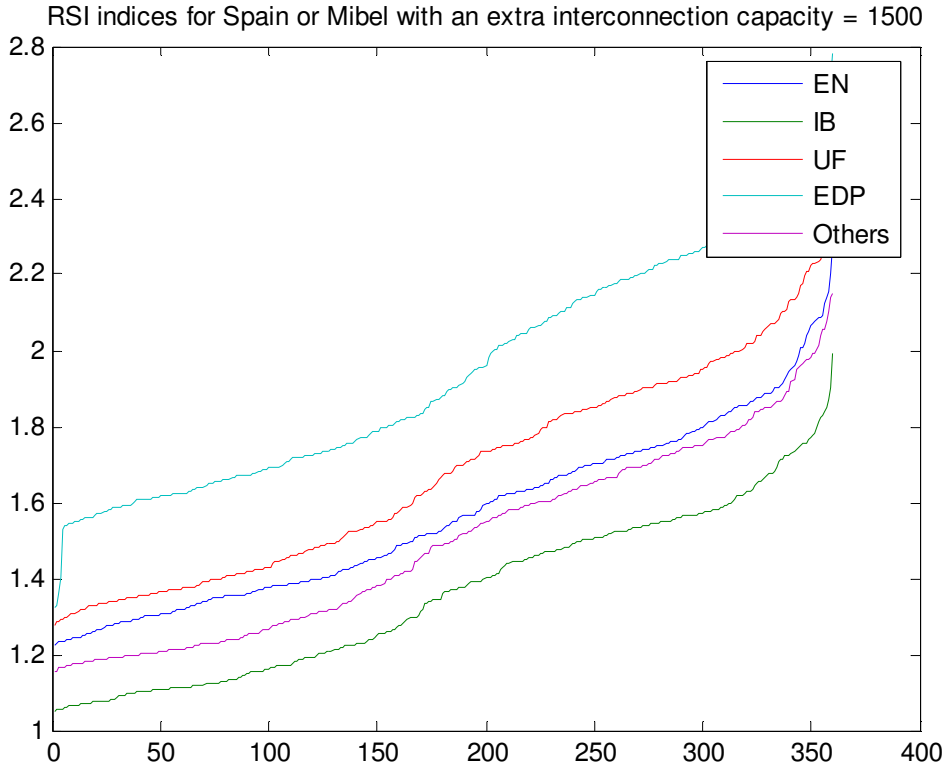


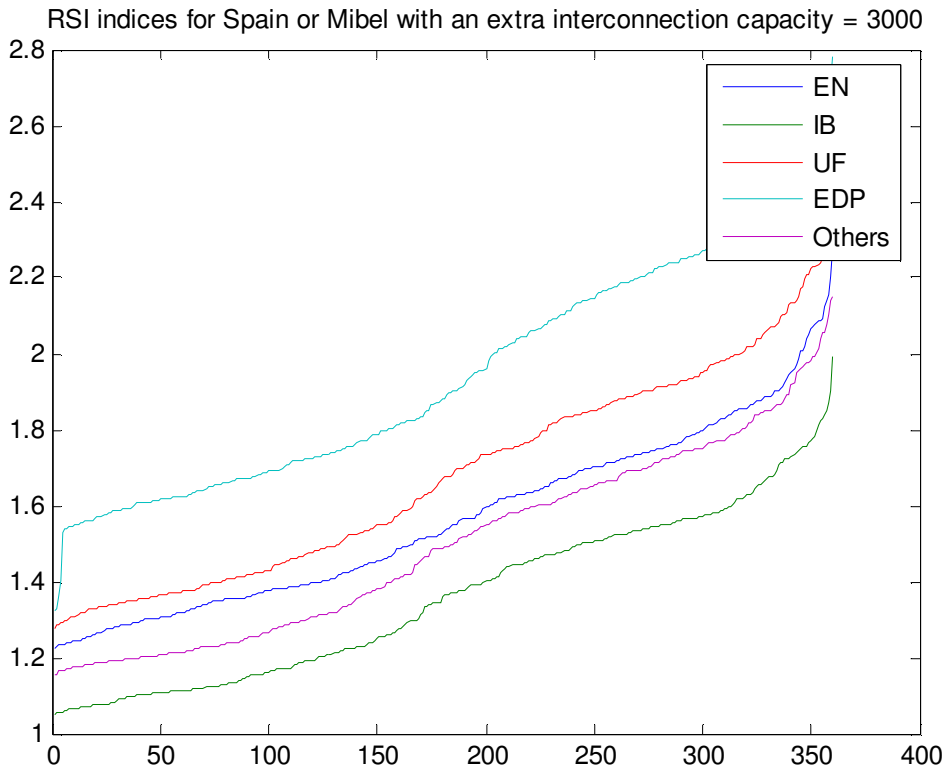
Figures 1 to 5 – Electricity prices for different increases in interconnection capacity

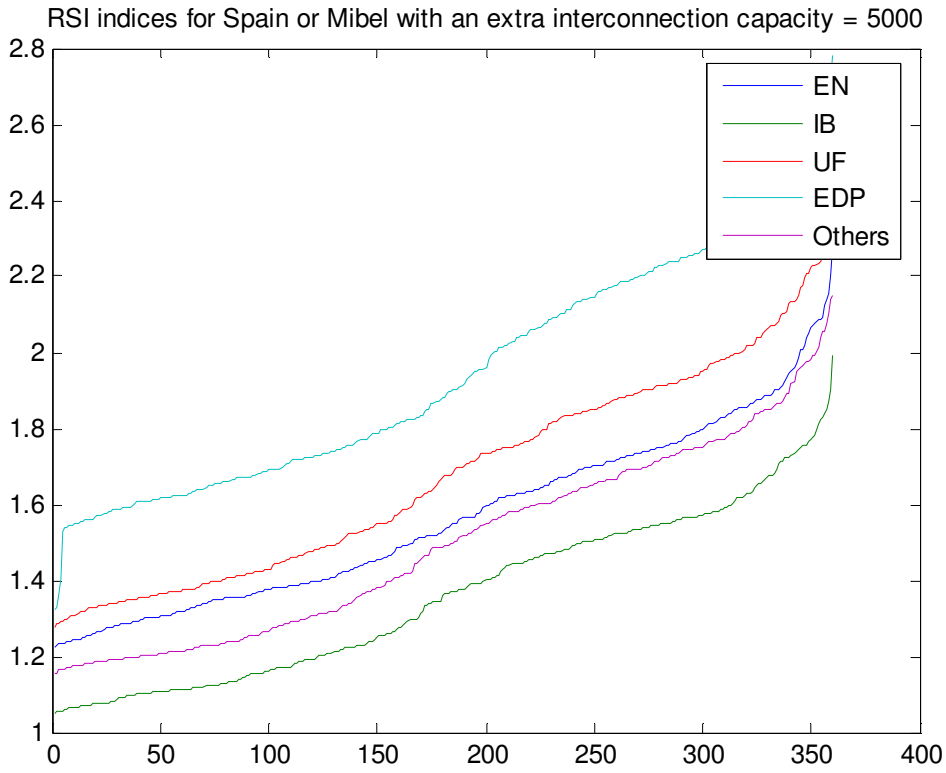
From these figures one can see very clearly that by increasing the interconnection capacity the electricity prices in Spain and Portugal become more equal. The price in Portugal drops radically whereas the price in Spain rises, but to a smaller extend. This is a logic results since the Spanish electricity market is of a much larger scale than the Portuguese one. When there is no extra interconnection capacity – current situation – prices in Portugal are higher than in Spain, and only very few times they are equal. Increasing the interconnection capacity with 1500 MW and 3000 MW brings the prices significantly closer to each other. By an increase in interconnection capacity of 5000 MW prices in Portugal and Spain become practically the same. With an extra interconnection capacity of 10000 MW results are similar to the case with a 5000 MW increase in interconnection capacity.

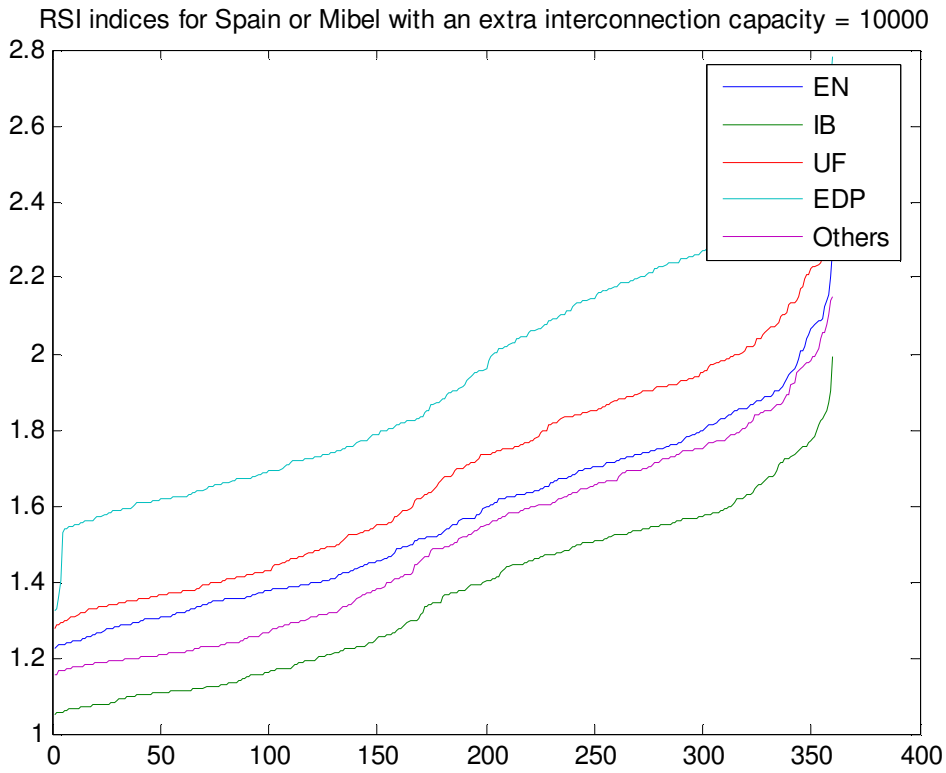
Secondly the Residual Supply Indices for Spain are compared in figures 5 to 8. Some important remarks have to be made to correctly interpret these graphs.
First of all, the Portuguese company 'EDP' does not enter the Spanish market directly but only through the interconnection. Therefore when considering only Spain this RSI-index has a different meaning than the usual one, namely the ratio of the total available supply over the total demand in Spain. Only when the electricity prices in Spain and Portugal are equal and we consider the whole Iberian Peninsula this RSI-index has the usual significance. However this only happens at some particular moments and can be noted a sharp falls in this curve for 'EDP'.
In addition it can be seen that the curve for 'Others' lies considerably low. This means that a great amount of capacity is not assigned to a specific firm. This is due to the fact that for some stations – especially renewables – the information of the ownership is not yet included. Since a big amount of this unassigned capacity in fact belongs to the big firms considered here the values of the RSI-indices in general overestimated, which implies an underestimation of their market power. As a result we can not make any conclusions based on the numbers of these indices. However we can still compare the different curves.


RSI indices for Spain or Mibel with an extra interconnection capacity = 0
EN
IB
UF
EDP
Others
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
50
100
150
200
250
300
350
400


RSI indices for Spain or Mibel with an extra interconnection capacity = 1500
EN
IB
UF
EDP
Others
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
50
100
150
200
250
300
350
400


RSI indices for Spain or Mibel with an extra interconnection capacity = 3000
EN
IB
UF
EDP
Others
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
50
100
150
200
250
300
350
400

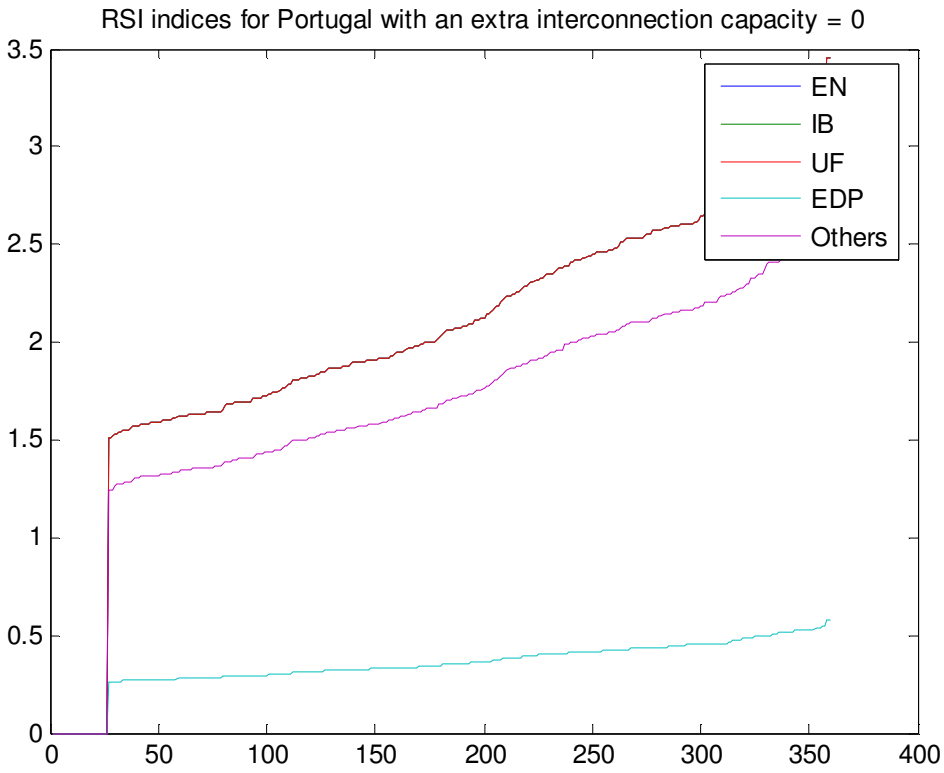

RSI indices for Spain or Mibel with an extra interconnection capacity = 5000
EN
IB
UF
EDP
Others
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
50
100
150
200
250
300
350
400

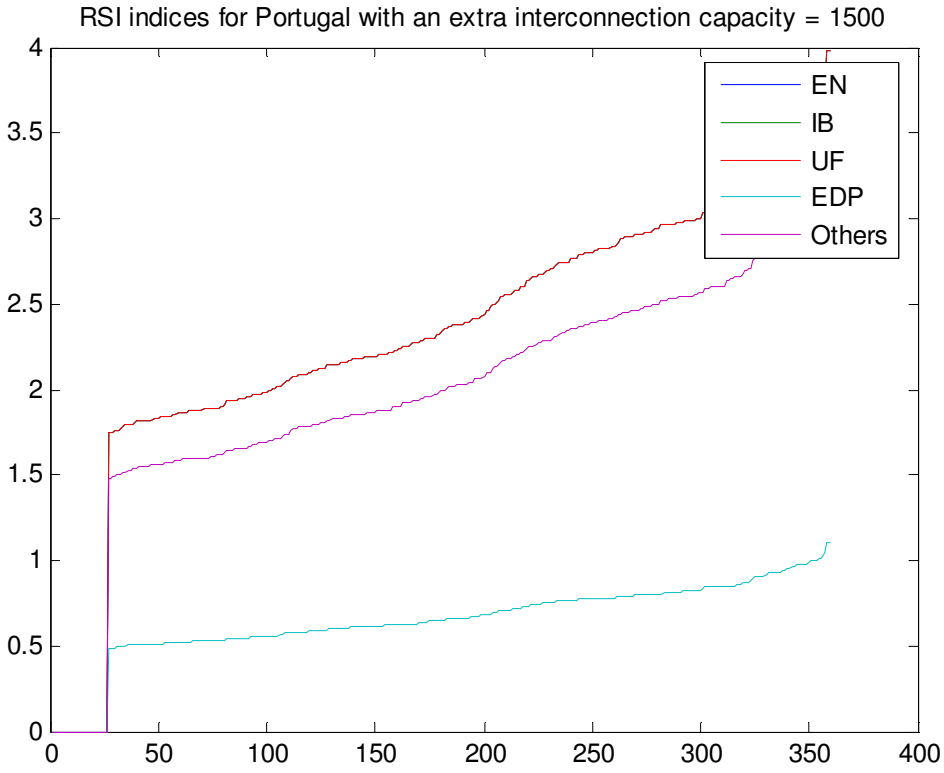


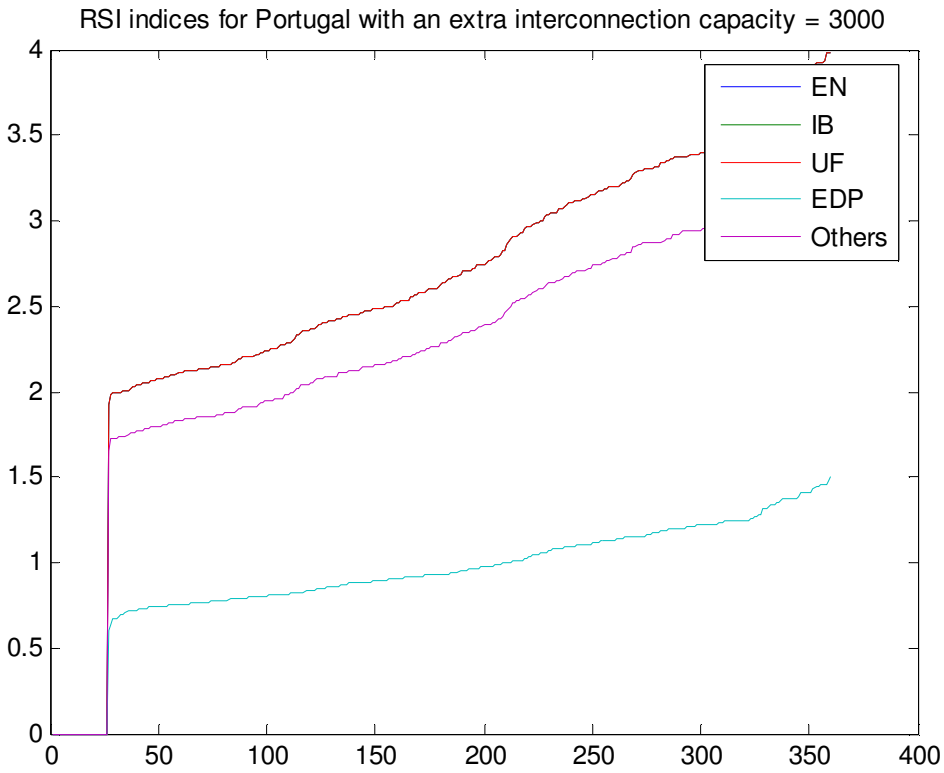
Figures 6 to 10 – RSI-indices for Spain or 'Mibel' for different increases in interconnection capacity

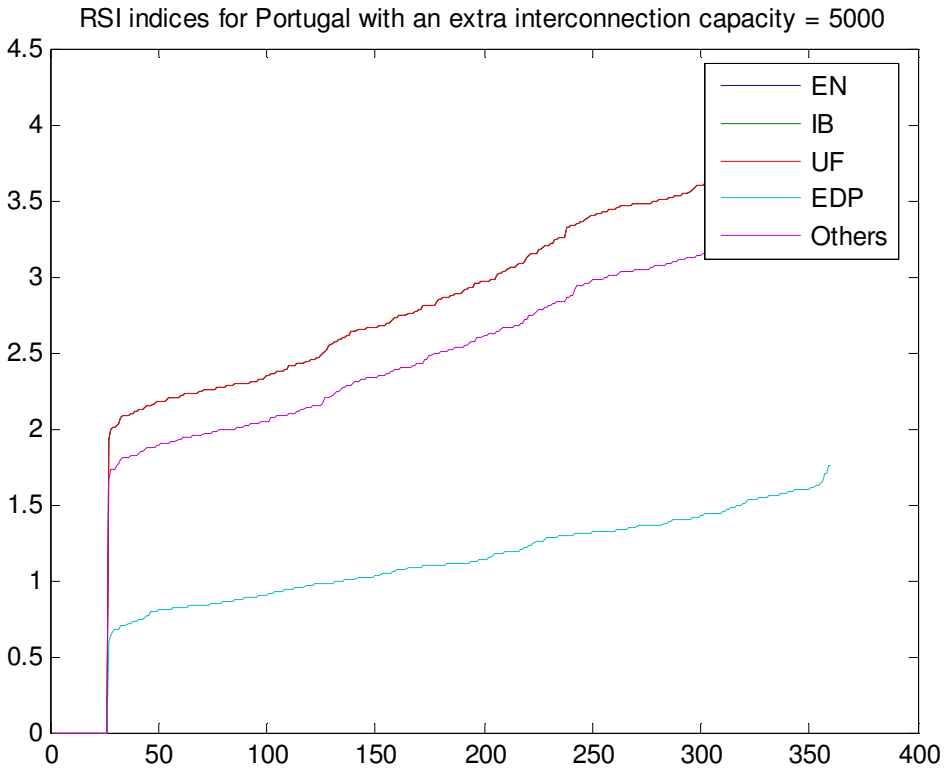
From the changes in the RSI-indices in Spain we can study the effect of increasing the interconnection capacity on the market power of the biggest firms in the Spanish market. As we can see from the graphs in figures 6 to 10 there is no big effect on the RSI-indices. So increasing the interconnection capacity will leave the market power of the current players on the Spanish market rather unaffected.

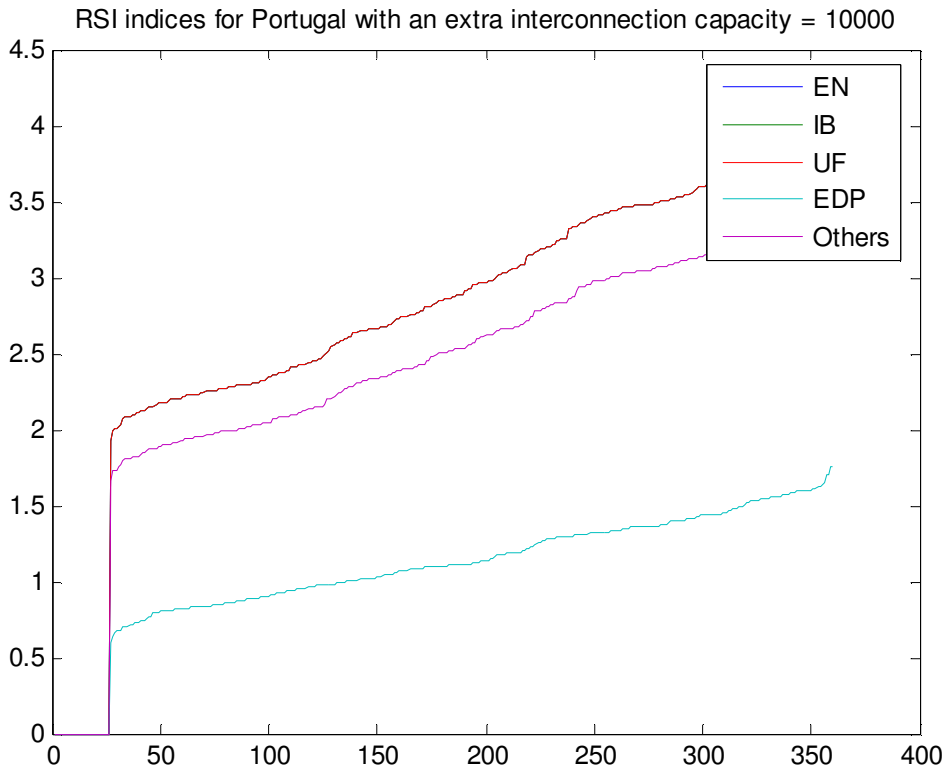
Next the same RSI-indices are evaluated for Portugal. Also here the previous comments apply. In this case 'Endesa', 'Iberdrola' and 'Union Fenosa' do not deliver directly to the Portuguese market. Therefore, these curves for the RSI-indices are all equal and depict the ratio of the total available supply over the total demand in Portugal.
Besides, also in this case the RSI-index for the group 'Others' is significantly low. So, again we cannot base any conclusion on the numeric values of the RSI-indices. Only a qualitative interpretation can be made.


RSI indices for Portugal with an extra interconnection capacity = 0
EN
IB
UF
EDP
Others
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200
250
300
350
400


RSI indices for Portugal with an extra interconnection capacity = 1500
EN
IB
UF
EDP
Others
0
0.5
1
1.5
2
2.5
3
3.5
4
0
50
100
150
200
250
300
350
400


RSI indices for Portugal with an extra interconnection capacity = 3000
EN
IB
UF
EDP
Others
0
0.5
1
1.5
2
2.5
3
3.5
4
0
50
100
150
200
250
300
350
400

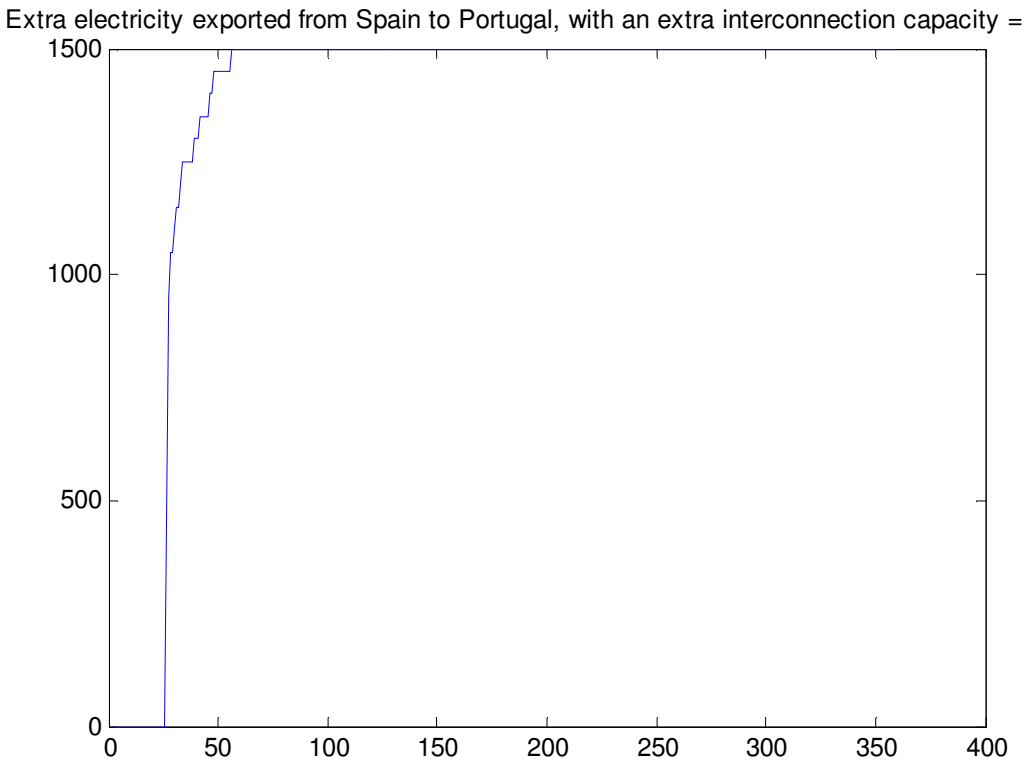

RSI indices for Portugal with an extra interconnection capacity = 5000
EN
IB
UF
EDP
Others
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
50
100
150
200
250
300
350
400

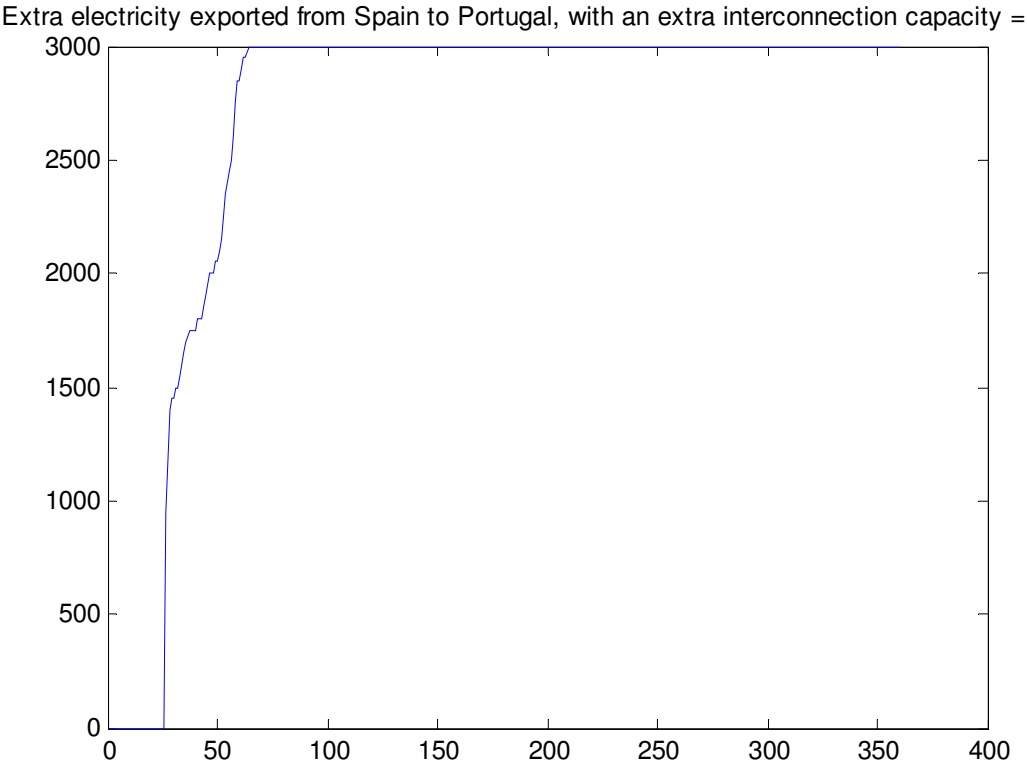


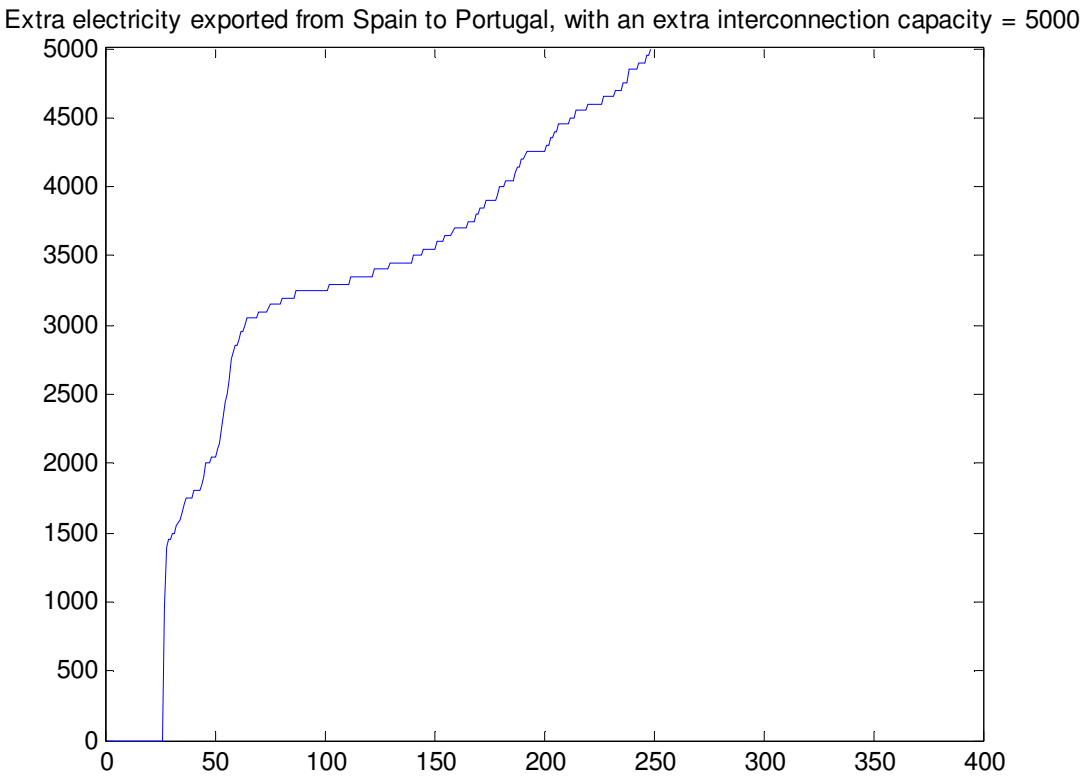
Figures 11 to 15 – RSI-indices for Portugal for different increases in interconnection capacity

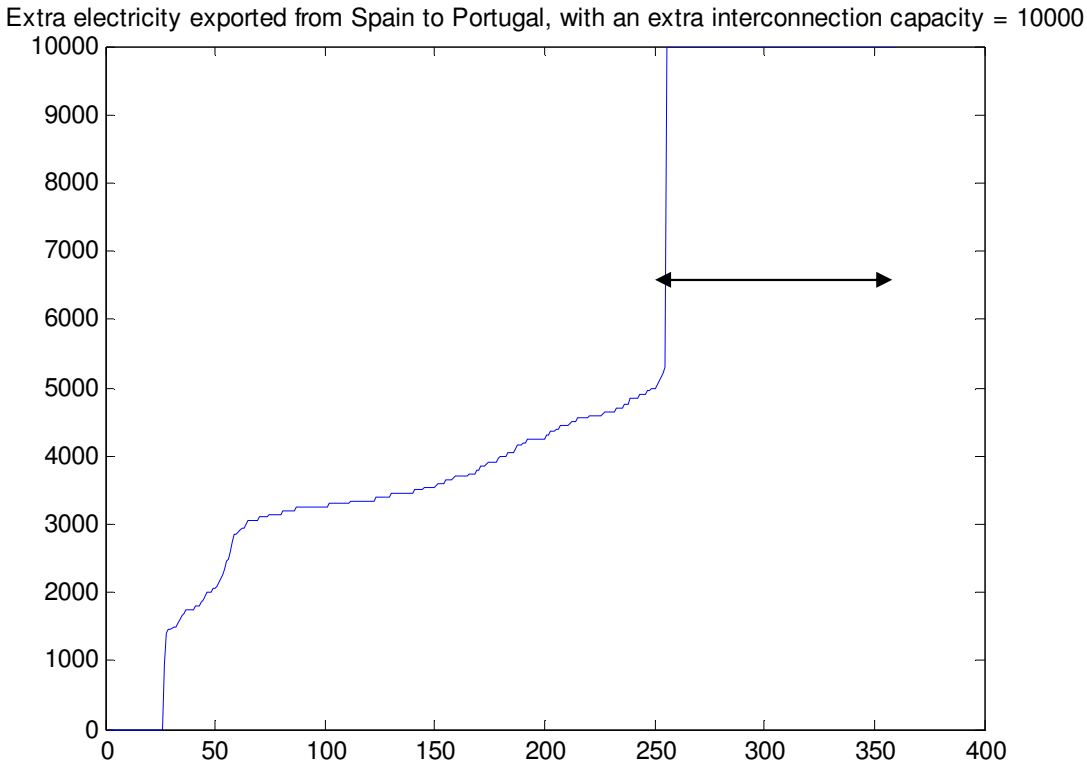
Looking at the graphs in figures 11 to 15 one can see that in Portugal increasing the interconnection capacity would have a significant effect of the market power of the largest market player, 'EDP'. The RSI-index for 'EDP' rises significantly when increasing the capacity by 1500 MW and considerably more when increasing the capacity by 3000 MW and 5000 MW. The additional effect of increasing the capacity by 10000 MW is negligible.

At last, a graph of the used capacity of the extra interconnection is plotted by the program. By studying these figures we can investigate to what extend the newly installed capacity would be used.


Extra electricity exported from Spain to Portugal, with an extra interconnection capacity = 1500
1500
1000
500
0
0
50
100
150
200
250
300
350
400


Extra electricity exported from Spain to Portugal, with an extra interconnection capacity = 3000
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400





Figures 16 to 20 – Used amount of the extra interconnection capacity

(Flow direction: Spain → Portugal)

From figures 16 to 20 we can see that up to an extra installed interconnection capacity of 3000 MW during a most of the time 100 percent of this extra installed capacity is been used. Even when an extra capacity of 5000 MW or 10000 MW is installed this capacity is completely used for a big part of the time. When looking at the figures for an extra installed capacity of 5000 MW and 10000 MW we observe that there seems to be a limit value of about 60 hours (indicated by the arrow) in which a very large amount of interconnection capacity is needed.

6. Conclusions and policy implications

From the simulation results we have seen that increasing the interconnection capacity between the Spanish and Portuguese electricity will greatly influence the latter one while leaving the Spanish market rather unaffected. Prices in Portugal will drop significantly and prices in Spain will rise a little bit. The effects on market power in Spain are negligible but in Portugal a large decrease in market power for 'EDP' is been expected.

Making statements on about what the optimal or ideal extra interconnection capacity would be is difficult and would require further investigation. From this basic study we can tell that increasing the interconnection capacity by more than 5000 MW would be economically inefficient. This can be assumed because by installing more than an extra 5000 MW the congestion of the interconnection doesn't seem to decrease unless a very big extra amount would be installed.

The results obtained in this study are a good indication but one should be cautious when interpreting them. The simulation can not include implications that would result from a change in strategies of the generating firms when both markets get more interconnected. Additionally the simulation can only be performed when data for the bids are available; as a result in order to be able to predict implications for the future, the model should be extended. Finally we left the interconnections between Spain and Morocco and between Spain and France out of consideration.

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