Impact of electricity retail price dynamics on the competitiveness of top exporting industries: analysis for the Portuguese and Spanish markets

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Master's in management dissertation

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2020/2021

Acknowledgements

This document is a landmark to my academic journey. It is the result of a very complete and intensive calendar year, but more broadly speaking, it is the result of a very challenging cycle of studies. I would like to take a moment to recognize the people behind this achievement.

First of all, a word of infinite gratitude to my family. To my parents, who I look upon as an example, for making my education a priority in your lives and for providing me with the best opportunities I could ask for. To my brother and sister, your support has no end. To all 4 of you, thank you for being my best friends. I can proudly say that today, I am the product of your values, of your support and your lessons. To my grandparents, thank you for living my happiness as it was yours. To all my family, a warm word of appreciation.

To my girlfriend, for making me grow every single day since we met, for all the patience, the support and for believing in me more than I sometimes do. To all my friends who have been by my side these past 5 years, thank you for the companionship.

To my supervisors, for all the incredible patience, availability and time taken to make this document exist. Your will to help is unmatchable and should undoubtedly be recognized.

I would also like to show my deepest appreciation to FEP. Looking back at my academic pathway, I enrolled in so many projects there, lived so many memorable moments, met so many wonderful people, that I can say with certainty that I can never say goodbye to such an institution. Thank you for receiving me so well. Thank you for providing me with the opportunities I had. Thank you for teaching me more than economics and management, because if there is something that a FEP student can say with certainty is that nothing is beyond his or her reach.

A word of appreciation as well to EDP Comercial, for risking and investing in me and my professional development. To all my team and its manager, thank you for the patience, and for the conditions you are giving me to thrive and learn.

And lastly, this document is the product of a journey that was not perfect. It is, however, my best work, and I am profoundly proud of what I have written in here. Thank you God for giving me the strength and will to complete this project.

Abstract

The last decades were marked by efforts at the European level for the creation of a single energy market. The constitution of the Iberian electricity market (MIBEL) represents a very important step to accomplish that goal, through the creation of a regional market allowing for the harmonization of electricity prices in the Portuguese and Spanish electricity regional pool (wholesale markets). However, that harmonization does not apply to the retail markets which raise pertinent questions namely those related to taxes, market structure and agent strategy. Moreover, strong price differences may involve significant competitiveness damages on exporting industries.

Given the identical conditions upon which electricity industrial retail prices are originated, a strong divergence seems to be an uncanny phenomenon to occur and most likely the differences in the consumption levels do not explain the whole problem. Why should the price be dropping so considerably in Spain while stabilizing in Portugal? Why should markets apparently so similar have such price differences? What variables could be driving these prices oftentimes in opposite direction, knowing that their market operator is the same, prices are formed under the same methodology and even key players are the same? What industries can see their exterior competitiveness affected by these divergences?

This dissertation aims at analyzing the price dynamics in the Portuguese and Spanish electricity retail markets and to access their influence on the competitiveness of top exporting industries in these countries, as well as to analyze the structure and market power in each one of the Iberian markets.

Keywords: Energy demand and supply; Prices; Firm organization and market structure; Electric utilities;

JEL Codes: Q41, L22, L94

Resumo

As últimas décadas ficaram marcadas por esforços a nível Europeu no sentido da criação de um mercado interno de energia. A constituição do Mercado Ibérico de Eletricidade (MIBEL) constitui um passo muito importante com vista ao cumprimento deste objetivo, através da criação de um mercado regional que permite a harmonização dos preços de eletricidade na pool regional Portuguesa e Espanhola (mercado grossista). No entanto, esta harmonização não se reflete nos mercados retalhistas, o que levante questões pertinentes, nomeadamente relacionadas com impostos, estrutura de mercado e estratégia dos agentes intervenientes. Mais ainda, as fortes diferenças de preços podem conduzir a danos significativos na competitividade exportadora das indústrias.

Dadas as condições semelhantes a partir das quais os preços de eletricidade para a indústria são formados nos mercados retalhistas, uma forte diferença de preços parece ser um fenómeno incompreensível e que certamente não será explicado completamente pelas diferenças de níveis de consumo. Porque é que vemos momentos de descida do preço no mercado Espanhol e de estabilização de preço no mercado Português? Porque é que mercados aparentemente tão similares têm estas diferenças de preços? Que variáveis podem estar a causar estas variações, por vezes em sentido oposto, sabendo que o operador de mercado é o mesmo, que os preços são formados com base numa mesma metodologia e até que os maiores agentes nos mercados retalhistas são os mesmos? E que indústrias podem ver a sua competitividade externa afetada com estas divergências?

Esta dissertação propõe-se analisar as dinâmicas de preços nos mercados retalhistas de eletricidade Português e Espanhol e estudar a sua influência na competitividade das maiores indústrias exportadoras nestes países, bem como analisar a estrutura e poder de mercado em cada um dos mercados ibéricos.

Palavras-chave: Procura e oferta de energia; Organização de firmas e estrutura de mercado; Indústria elétrica

JEL Codes: Q41, L22, L94

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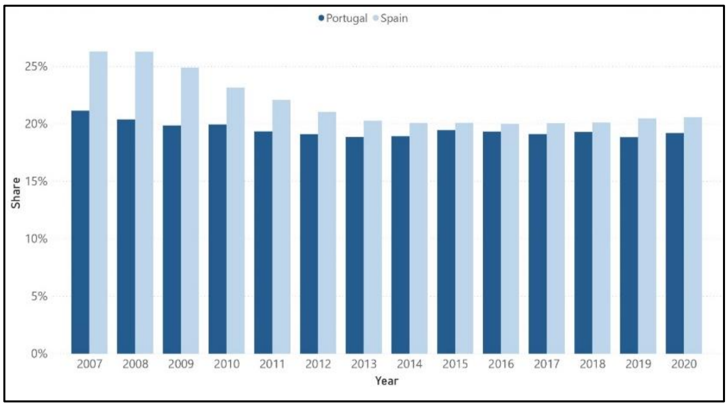
1. Introduction

Electricity is a commodity with great value, not only to the end-user but also to the economy of a given country, whether by the impact it has on productive processes or by being a universal need for every person, which causes the electricity industry to be of massive size and of great value added. A well-organized electricity system can fuel all sectors of the economy, from the smallest of SME's to the largest of industries, and can foster the development of new technologies and production systems. In particular, one of the largest consumer of electricity is the industrial sector. Both the Portuguese and the Spanish economies generate a large portion of its gross domestic product from this sector:

Figure 1. Share of the industry sector in the gross domestic product (GDP) in Portugal and Spain



Source: own elaboration based on Statista[1]

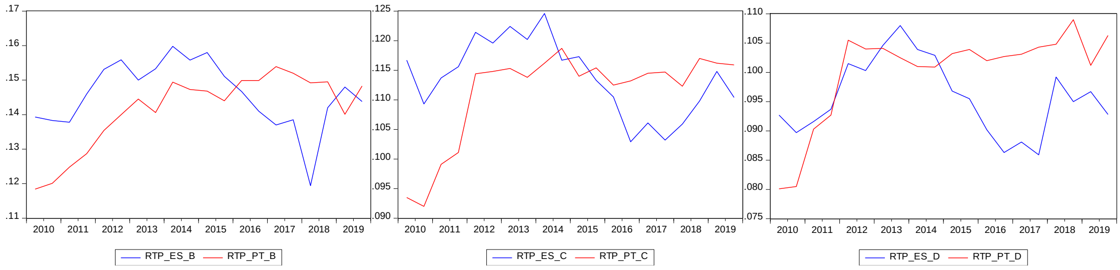
Given the importance of electricity to all the economy, the past decades have paid much attention to the structure of electricity markets and have undoubtedly been disruptive when it comes to legislation regarding the electricity market, not only in Europe, but in many countries of the world. These measures aimed at bringing competition to generation and retail activities, which were formerly bundled into a vertical value chain, oftentimes under a monopoly regime, with absolutely no seizing of market mechanisms. The introduction of competition came to revolutionize market designs and its success is yet to be considered consensual, as authors like Defeuilley (2009) claim that retail competition has been disappointing, and S. Littlechild (2009) defending that it exceeded expectations.

Nevertheless, Portugal and Spain are a success case of electricity market integration, following the regulatory measures taken by the European Union on the pursuit of an internal

[1] Data retrieved from https://www.statista.com/statistics/372187/share-of-economic-sectors-in-the-gdp-in-portugal/ for Portugal and from https://www.statista.com/statistics/271079/distribution-of-gross-domestic-product-gdp-across-economic-sectors-in-spain/ for Spain

energy market. They have a common market operator, a very similar price formation system, identical relative generation capacity, similar players running the competitive activities of the market and a shared vision for the development of the so-called MIBEL. With all these similitudes, industrial retail price dynamics were expected to be identical. Empirical evidence rejects this hypothesis, as seen below:

Figure 2. Retail prices for industrial consumers of consumption bands IB, IC and ID



Source: own elaboration based on Eurostat's bi-annual prices

Knowing that there are significant price differences at the retail price level for industrial consumers, and a recognized shortage of literature on the drivers of retail prices, this dissertation proposes an econometric model that analyses what causes price dynamics to occur the way they do in Portugal and Spain, for the period since 2010 to 2019. Results essentially show that customers might not be capturing all the benefits from competition, in line with Taber, Chapman, and Mount (2005) and Apt (2005). After demonstrating this, we identify through a set of variables related to exports and electricity costs, a group of industries that can be affected the most by the price gaps between both countries, and at a more generalized level, by the price gaps compared to the rest of the world, which is an hypothesis recognized by several authors, such as Kádár Horváth (2014) and Morey and Kirsch (2016) and more importantly by Rademakers et al. (2020).

This document is organized as follows: chapter 2 explains concepts that are essential to the understanding of electricity markets in Europe and in MIBEL. Chapter 3 presents a literature review on the liberalization of the electricity markets and on the introduction of competition in retail markets. On chapter 4, the state of development of retail markets in Portugal and Spain is presented, as well the components that take part in the formation of retail prices. On chapter 5, it is discussed the literature findings on drivers of retail prices, the variables and the econometric model to be conducted and its results. The output of chapter 6 is the identification of top exporting industries. Finally, on chapter 7, the conclusions, limitations, and future research possibilities related to the present dissertation are presented.

2. Conceptualization and background

The goal in this first chapter is to explain the electricity value chain – without expanding much on the details of each activity – and link its structure to the recent developments brought to the table by the European Union directives regarding legislation on energy policies. After this, the current players and characteristics operating in the value chain of the two countries studied in this dissertation are presented.

2.1. Electricity value chain

The value chain of electricity is a sequence of the following activities: generation, transmission, distribution and retailing. Generation of electricity comprises the activity of producing electricity from fossil fuels or from renewable energy sources. It is the starting point of the value chain and it is traditionally measured in each country according to its production mix, i.e. the share that each source represents on the final output. Since electricity is produced in areas separated from each consumer's delivery point, electricity needs to be transported. The transportation network links generation plants with the distribution systems, which then provide electricity to end-users. Traditionally, in order to minimize inefficiencies, the transportation activity is made at very high voltage levels. No electricity market is possible without this network, which enables supply regardless of the distance to the production centers. The next stage of the value chain is the distribution activity. After the transmission in high voltage levels, the distribution grid connects the transportation network to the end-users, while at the same time decreasing the voltage levels so that consumers can receive electricity in their spaces. This grid is composed of high, medium and low voltage infrastructures. Lastly, the final activity is retailing and it refers to the commercialization of electricity to the end-user, according to a given set of conditions and terms for the supply of energy. This is the phase of the value chain that has direct impact on the consumer, and it is where this dissertation will focus most of its attention.

2.2. European legislation

Up to the 90's decade, this sector was not seen as a sector where competition could arise. In fact, most EU-member states had only one player operating the whole value chain of electricity, which was highly regulated at the time. Most of the times, this monopoly was explored by state-owned companies. Considerably high capital investments necessary at the beginning of the value chain, namely in production plants, transportation network and distribution grid infrastructures also posed a significant barrier to the entry of new companies.

However, following the realization of the European Common Market by the end of the 90's decade and the success case of the United Kingdom's liberalization efforts, criticism started to appear over this business model. The disparity of electricity prices between member states caused a shared interest to reform the electricity regime. In fact, these differences in energy prices became an important factor influencing the competitiveness of European economies, and caused fear of relocation of production to countries with significantly better electricity prices (Heddenhausen, 2007). As a consequence, the European regulator found vital the harmonization of the EU's internal energy market. Three main goals were pursued, according to Domanico (2007): the creation of an internal energy market, which would increase commercial relationships between member states by fostering cross-country competition and thereby potentiating incentives towards an efficient market; guarantee security and continuity of supply throughout the EU; promote environmental protection through a set of rules adopted at the EU level that every member state should follow. Ultimately, the goal was to improve consumer welfare, as competitive markets promote customer choice, lower prices and higher quality services for its end-users.

The European Union and the Member States adopted the Directive 92/96/EC, formally introduced on December 19, 1996. Also known as the "first energy package", it introduces the idea of vertical unbundling: the separation of potentially competitive activities – generation and retail supply - from the natural monopolies where competition would be economically ineffective – transportation and distribution (Jamasb & Pollitt, 2005). Among other measures, the directive further states that all electricity generators should have access to the transportation and distribution network at a reasonable price, a concept also known as "third-party access", that retailers could freely compete in the market to acquire customers, and that larger customers could choose their retail supplier (Pollitt, 2019). Companies that were vertically integrated no longer could generate, transport, distribute and supply electricity while being in charge of the management of the transmission and distribution system.

A second energy package was launched in 2003, with the implantation of two other measures for electricity: the directive 2003/54/EC and the Regulation (EC) No 1228/2003 regarding the conditions for access to the network for cross-border electricity trading[2]. It

[2] Florence School of Regulation, available on https://fsr.eui.eu/the-clean-energy-for-all-europeans-package/

demanded that by July 2004 all non-household customers should be able choose their preferred electricity supplier, and that this freedom of choice of retail supplier to all domestic and industrial customers was a reality by July 2007. Another important measure it introduced to be achieved by this same date was the requirement to legally unbundle the transmission system operators (TSO) and distribution system operators (DSO), which means that a single company could operate in only one of the levels of the electricity value chain. Moreover, the directive demanded free entry to the generation activity and the creation of a National Regulatory Agency for energy matters, with a degree of independence from the government.

A third energy package was adopted in 2009 in an attempt to strengthen the liberalization efforts already taken. It imposed new unbundling requirements through the introduction of ownership unbundling, meaning that no company operating at the supply or production level was allowed to hold a majority share or interfere in the processes of a TSO. Among other measures, the package further established ACER – Agency for the Cooperation of Energy Regulators – to work as a forum for national regulators' disputes and for the monitoring of cross-border competition and demanded increased electricity generation coming from renewable sources.

Through this strong regulatory statement, the creation of an internal energy market in the European Union is now a reality, although still far from completion. Nevertheless, the focus on enhancing competitiveness, transparency and customer welfare had a clear impact on the design of the electricity value chain. Vasconcelos (2004) summarizes the European directives in a very assertive way:

Table 1. Summary of EU electricity directives

EU electricity directives				
	Most common form pre-1996	**1996 directive**	**2003 directive**	**2009 directive**
Generation	Monopoly	Authorisation / tendering	Authorisation	Authorisation
Transmission & distribution	Monopoly	Regulated TPA / negotiated TPA / single buyer	Regulated TPA	Regulated TPA
Supply	Monopoly	Accounting separation	Legal separation from transmission and distribution	Ownership separation from transmission and distribution
Customers	No choice	Choice for eligible customers (larger ones)	Choice for all non-household (2004) and all (2007)	Choice for all customers
Unbundling	None	Accounts	Legal	Ownership
Cross-border trade	Monopoly	Negotiated	Regulated	Regulated and monitored through ENTSO-E
Regulation	Government department	Not specified	Regulatory authority	Independent regulatory authority

Source: own elaboration based on Vasconcelos (2004)

2.3. The Portuguese and Spanish agents in the value chain

Table 2. Portuguese and Spanish value chain and enrolled entities

Level	Portugal	Spain
Production	Competitive activity, with free entry and exit conditions for companies. Two production regimes are defined: the ordinary regimen – electricity generated from traditional and non-renewable sources – and the special regimen – for electricity generated from renewable sources – subject to special legal boundaries and requisites.	Competitive activity, with no entry barriers to new entrants. Two production regimes used to exist – the ordinary regime and the special regime – however the Power Sector Act (24/2013) abolished this distinction from the Spanish regulation. Currently, all technologies participate in the market in ensemble.
Transmission	Activity managed as a natural monopoly, the Portuguese transmission system operator is REN – Redes Energéticas Nacionais, S.A, who has the responsibility of planning, building and maintaining the quality of the transmission grid, as well as its modernization and future investments. Moreover, it has the role of ensuring the security of the supply of electricity and its continuous flow.	Activity managed as a natural monopoly, the entity responsible for this activity is REE – Red Eléctrica de España. The company has the same responsibilities of REN, its Portuguese similar. In fact, the Portuguese and Spanish transmission networks are connected, enhancing cross-border trades and Iberian cooperation.
Distribution	Activity managed as a natural monopoly, the national DSO in Portugal is E-Redes – Distribuição de Eletricidade, S.A., a subsidiary of the EDP Group.	activity managed as a natural monopoly, more than one player operates as a DSO in Spain. In fact, there are four companies covering the distribution grid: Endesa, Iberdrola, Gas Natural Fenosa and EDP (Viesgo was a fifth player, but it was recently acquired by EDP).
Retailing	competitive activity, retailers do not have the obligation to have physical connections to the grid, as they have the right to access it under the payment of the access tariffs defined by the country energy regulator. They supply electricity at the conditions they define, having the responsibility to deliver quality and continuous supply, as well as access to information in a clear and transparent way.	competitive activity, retailers do not have the obligation to have physical connections to the grid, as they have the right to access it under the payment of the access tariffs defined by the country energy regulator. They supply electricity at the conditions they define, having the responsibility to deliver quality and continuous supply, as well as access to information in a clear and transparent way.
Regulation	this role is attributed to Entidade Reguladora dos Serviços Energéticos (ERSE)	the role of market supervision is a responsibility of CNMC – Comisión Nacional de los Mercados y la Competencia

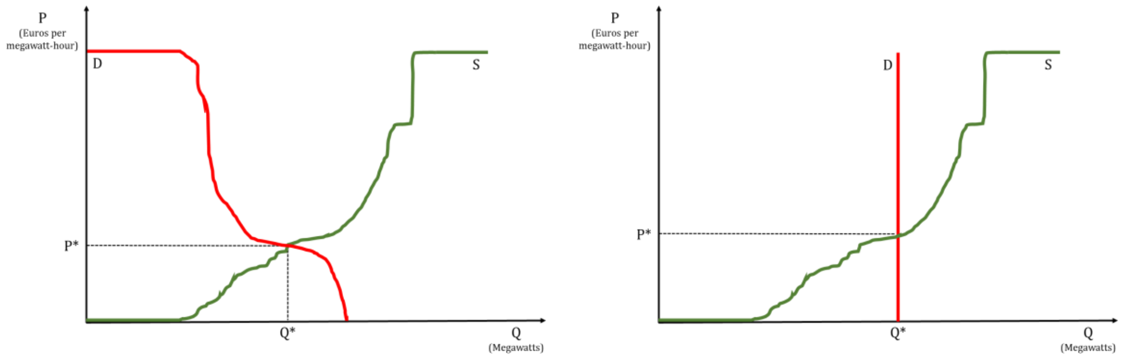
Source: own elaboration based on ERSE and CNMC

2.4. Wholesale market models: pools

It is important to understand how wholesale markets work regarding price settlement. To do that, let's analyse the most common market architectures: pool mechanisms, bilateral contracts and hybrid models. To explain these concepts, the work of Praca, Ramos, Vale, and Cordeiro (2003) was very helpful.

One of the most common market designs for the spot market is the pool model, which can be also called "power exchange". A pool is a competitive marketplace that is based on the principle of equilibrium between supply and demand. It can be a symmetric pool or an asymmetric pool – in the former, suppliers and consumers influence market price, and in the latter, only sellers compete against each other – and the market operator plays a pivotal role on all these different arrangements, being responsible for receiving and organizing supply and demand bids and applying a market clearing tool to define the market price, the most common of ones being the standard uniform auction. Typically, the market operator builds a supply curve and a demand curve for each negotiation period. On symmetric pools, supply bids are sorted by ascending price and demand bids are sorted by descending price. On asymmetric pools, the difference is that demand is inelastic, as the market operator receives only one bid corresponding to the sum of all demand needs, with no price discrimination. The market clearing price and the market clearing quantity is given by the point at which both curves intersect and is promptly communicated to all agents involved, particularly to the system operator for technical feasibility validation. If feasible, bid matching occurs and a viable dispatch program is defined for each negotiation period.

Figure 3. Symmetric and assymetric pools



Source: own elaboration

Electricity markets are mostly marginalist markets, where the market price is set by the marginal cost of the last producer needed to fulfil the demand volume. Thus, that price becomes the marginal price of the system, market clearing price or market equilibrium price. Producers receive this amount per unit produced and retailers pay this amount per unit consumed, regardless of the bid values they sent to the market operator. Looking at figure 3, the pair (Q*, P*) represents the pair (market clearing quantity, market clearing price). All sellers' bids offering lower prices than P* are accepted, which means that these generators will produce Q* megawatts of electricity. Similarly, all buyers' bids offering higher prices than P* are accepted, which means that these consumers will receive Q* megawatts of electricity.

As previously mentioned, sellers and buyers have contradictory behaviours and goals. On the one hand, sellers want the highest possible price: at all times sellers will compete with each other because all of them want to sell a given production volume at the highest price possible in order to maximize profits, and each unit they produce is no different than the one their competitor just produced, meaning that there is no differentiation between generators. On the other hand, buyers want the lowest possible price to reduce power expenditures. This process of seeking the most profitable solution for both players has received large attention at the scientific level, oftentimes studied with game theory approaches due to the possible outcomes and the decision-making processes behind these market architectures.

A consequence of pool models is that generators do not know who they are generating electricity to and consumers do not know who generated the electricity they receive. Bilateral contracts (also referred to as over-the-counter) aim to solve this issue by enhancing on a more "personalized" negotiation process. In this market model, buyers and sellers interact directly with one another to achieve an agreement about power supply and receipt. These agreements are much more flexible, as involved parties can formulate their own contract terms, pending on validation from the system operator (the TSO).

Hybrid models offer consumer choice. They combine features of pool and bilateral contract models and allow for both pool contracts and bilateral contracts to happen simultaneously. This means that it is up to buyers and sellers to decide if they desire to negotiate the contracts at the pool level and accept the pool market price or if they desire to negotiate through bilateral contracts and establish their own conditions, since the pool model is not mandatory. A third option arises through the usage of both negotiation processes, which might originate advantageous conditions whenever market imperfections occur.

2.5. MIBEL integration and functioning

By the end of the 90's decade, achieving a single energy market was unrealistic for the short term being, considering that there were a variety of market models and different degrees of liberalization throughout EU member states. Moreover, there were geographical constraints, as interconnection capacity between countries was still limited. Thus, the efforts put forward by the European Union in order to create and develop a single energy market were consolidated by the definition of regional energy markets. The two countries of the Iberian Peninsula were always very connected economically, so a common electricity market was considered to be a mutual interest project. Following the European directives and the EU's goal of an internal energy market, Portugal and Spain joined forces and established MIBEL, the Iberian electricity market.

MIBEL is organized in a hybrid model as it hosts a symmetric pool for the day-ahead and the intra-day markets at the spot level and the possibility to take part in bilateral contracts, as well as several products at the derivatives market. MIBEL's wholesale market is materialized in the Iberian market operator (OMI), split into two poles: a Portuguese pole focused on the derivatives and market (OMIP) and a Spanish pole focused on managing the spot market (OMIE).

2.5.1. OMIE

OMIE is the nominated market operator for the spot market in the Iberian Peninsula. The electricity spot market is the marketplace where electricity is traded to be delivered in a very short amount of time. The period for delivery is variable, depending on the sub-market we consider, as OMIE's spot marketplace is split into two parts: the day-ahead market and the intra-day market. However, for the purpose of this dissertation, only the day-ahead market will be explained in higher detail.

The day-ahead market is a voluntary pool that offers the possibility for generators and consumers to handle electricity transactions for each of the 24 hours of the day after the deadline date for the reception of bids for the session. OMIE conducts the process of bid matching and price settlement for each of the 24 negotiations periods of the day-ahead market, through receiving bids, calculating the intersection between aggregated supply and aggregated demand curves and determining the price to be paid to all producers by all consumers, which is the lowest price that satisfies demand. All results are later sent to the system operator (namely REN and REE) for balancing processes.

2.5.2. OMIP

To prevent retailers against the risk characteristic of the spot market, derivatives contracts were introduced in order to allow players to enter hedging strategies that helped them mitigate the volatility of prices and volumes. These contracts are agreements that have an underlying asset as a basis for valuation, namely electricity, and can be of physical delivery when seller and buyer parties agree on the delivery and reception of the underlying asset or of financial delivery, where the open positions in the contract are settled financially (cash-settlement) and the delivery of the underlying asset occurs fictionally.

OMIP was created as the market operator for derivatives and bilateral contracts, creating the possibility for financial delivery as well. It operates alongside with OMIClear, the clearing house and central counterparty to the contracts negotiated in OMIP. Contracts offered in OMIP have different maturities (days, weekends, weeks, months, quarters and years) and range between futures, forwards, swaps and options. Once again, for the purpose of this dissertation, we will lay our focus on futures contracts, which are a legal agreement celebrated between a buyer and a seller, where the seller agrees to deliver a certain amount of electric energy in a given place at a given time at a specific exercise price, which is to be paid when the contract reaches its maturity date. Futures contracts in OMIP are standardized regarding volume, minimum price variation (tick), maturity and other characteristics, regardless of whether they are of physical or financial delivery. OMIClear stands in the way of both parties at all times by taking the symmetrical position to the one that the investor opened, becoming the buyer to every seller and as a seller to every buyer.

2.5.3. Market splitting

MIBEL has two price zones, namely the Portuguese price zone and the Spanish price zone. Price homogeneity in MIBEL depends completely on the interconnection capacity between both countries. Thus, if the cross-border interconnection is congested, there might be an impossibility to transport the energy flow between the two neighbouring countries. For MIBEL, this problem is solved through a mechanism called "Market Splitting", which can be seen as a spread between prices for Portugal and prices for Spain. In practice, what occurs is a different price between both countries, with the price of the importing area being higher. There is a clear goal to minimize the occurrence of this phenomena, as well as a commitment to increase interconnection capacity, celebrated during the formation of MIBEL.

3. Literature review on market liberalization and retail markets

The topic of the liberalization of electricity markets and the success of retail markets is largely abundant on literature. Following the success cases of other industries, such as telecoms and airlines (Mackay & Mercadal, 2021) and the successful reforms in the electricity markets of Chile, the United Kingdom, the Nordic countries and Texas (Joskow, 2008) the process of liberalizing wholesale and retail electricity markets began in Europe too.

The goal for these reforms was universally accepted to be the creation of "new institutional arrangements for the electricity sector that provide long-term benefits to society and to ensure that an appropriate share of these benefits are conveyed to consumers through prices that reflect the efficient economic cost of supplying electricity and service quality attributes that reflect consumer valuations" (Joskow, 2008). The increased efficiency was only to be achieved if competition should introduce new dynamics on end-user prices – in favour of a decrease – as well as the entry of new players to the market and the overall increase in service quality, which would potentiate a broader range of choice to consumers.

A good starting point, perhaps, would be the work of Jamasb and Pollitt (2005), on which the authors explain what makes the electricity supply industry so unique, namely: the large sunk costs that are needed at the entry level; the vertical stages of production, each of which with different optimal scales; and the fact that electricity is a non-storable good, which means that it requires constant balance between supply and demand.

Klitgaard and Reddy (2000), which analyze the fundamentals behind deregulating electricity markets. The authors contest the historical view that one large firm operating under a monopoly regime could achieve better performance in conducting the activities of the electricity value chain than several smaller firms and highlight that a regulated system of monopoly suppliers has no need for a wholesale market, facing little to no competition pressure to lower their cost of production. In contrast, in a model with competition, the creation of a wholesale market causes power plants to lose guaranteed return, which means that they will have to compete on production costs, enhancing innovation expenditures as so to beat the competition.

Schnittger and Adamson (2001) follow these arguments and claim that while there is a consensual need for efficient wholesale markets, they are of limited value until the price information they carry reaches consumers. Indeed, it is important to guarantee that price savings realized at the wholesale level benefit consumers. According to the authors, market prices convey information about the value of the underlying product, and customers will not be active in the market if they don't capture it. This sets the motto to the work of Nagayama (2007), who studied the effect of reforms in the electricity supply industry in developing countries and concluded that neither unbundling nor the creation of a wholesale pool market by themselves are guarantees of lower prices, as actually price increased when considered alone. This finding is in line with the work of Hattori and Tsutsui (2004), who considered a very similar time period (1987-1999) and reached the exact same conclusion. However, Nagayama (2007) stated that unbundling the value chain alongside with the introduction of an independent regulator may reduce prices.

Joskow (2008) took the topic further and defined 11 desired architectural features that a liberalized electricity market should have in order to succeed. Naturally, included in these 11 features were the creation of a wholesale market, the unbundling of the value chain and the introduction of an independent regulatory entity, among others. One of the desired conditions was the establishment of the role of retailers and promote competition in the retailing activity in order to provide higher stability to end-users.

This topic of retail competition is also very relevant to the literature. Joskow (2000), for instance, asks what is the added value that electricity retailers provide. The author begins by stating that if the responsibility of these agents is merely buying electricity in the wholesale market and resell it at the retail market, then there is very limited value added to this kind of competition. In fact, the author claims that costs can actually increase due to marketing, advertising and transactional costs and that electricity retailers should focus on providing other value added services than competition on price. In a response to these arguments, S. C. Littlechild (2000) poses great confidence in the market mechanisms that regulate competitive markets. His take was that in the long term, efficiency gains may offset the costs highlighted by Joskow (2000) and that retail markets are essential to potentiate wholesale market's advantages. Moreover, the author says that a retailer exposed to competition absolutely needs to be effective on its wholesale buying and retail selling strategies, which have impact on market share and on the financial performance of its business. In contrast, a retailer with monopoly power does not risk market share and therefore its profits are independent of its wholesale purchasing strategy or selling conditions.

Concettini and Creti (2015) underline that retailers have three principal dimensions that have impact on retail electricity competition, namely efficiency, differentiation and equipment innovation. The first one comprises direct efficiency gains from the retail activity, as seen above with S. C. Littlechild (2000), and indirect gains achieved via applying downward pressure on transmission and distribution costs, for instance. The second dimension is also highlighted by Joskow (2008), who underlines the potential for new offers, new contractual arrangements – such as green packages of energy – and an array of complementary services, such as risk management or energy management services. The third dimension is related, for example, with the installation of smart metering and reading devices.

Concettini and Creti (2015) recognize the lack of a consensus on the set of indicators to measure the success of market liberalization. While some authors focus on the dynamics related to the switching rates (see, for instance, Valquaresma (2015) and von der Fehr and Hansen (2010)), others such as Taber et al. (2005) and Apt (2005) focus on dynamics in retail prices. This is where this dissertation will focus as well.

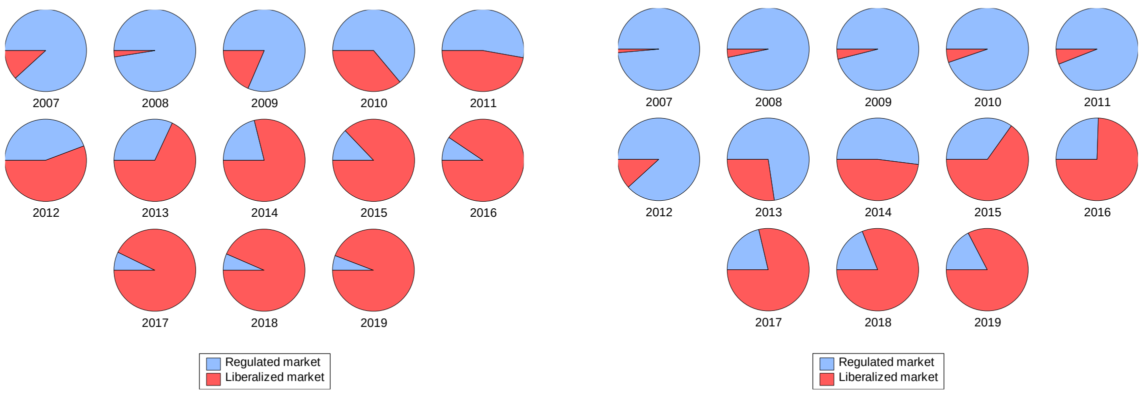
4. Retail market situation and retail price breakdown

Electricity retailing traditionally comprises two markets: a liberalized, competitive market, and a reference, regulated market. The past years were characterized by a growth in the importance of the liberalized market, though Portugal and Spain still face the transition from the former to the latter, as both countries still have regulated markets operating, with suppliers of last resort providing regulated tariffs to the consumers that have not switched to the liberalized market. The purpose of this chapter is to analyse the evolution of the liberalized retail market of each country in the past years, as well as understand how this market is organized specifically for industrial consumers, regarding dimension of demand and number of retailers.

4.1. State of the art in Portugal

Portugal's market liberalization process has been progressively conducted through the extinction of regulated tariffs and the usage of transitional tariffs envisaged by ERSE. Particularly for industrial consumers, January 2011 marked the starting point from which the process was accelerated, with the extinction of regulated tariffs applicable to customers with consumptions in very high voltage (VHV), high voltage (HV), medium voltage (MV) and special low voltage (SLV), typically the most representative for this customer group.

Figure 4. Evolution of the market share of the liberalized market in Portugal (consumption and # of customers)



Source: own elaboration based on ERSE's monthly bulletins and annual reports on the electricity retail market

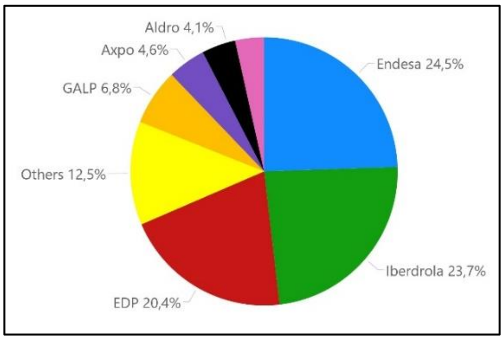
Figure 4 represents the evolution of the penetration of the liberalized market as opposed to the penetration of the regulated market in Portugal since 2007. Clearly the growth of the liberalized market was intensified from 2008 onwards, as the share of the overall electricity consumption associated with the liberalized market was just 3% in 2008, ultimately growing to 95% in 2019, mainly due to the new suppliers entering the market and to the extinction of regulated tariffs. During the past 5 years, there seems to be a trend of stabilization regarding the share of overall consumption associated with the liberalized market. As for the number of customers with contracts celebrated with a retailer on the competitive open, growth is similar, yet the market share of the liberalized market is less than 83%, as a significant parcel of LV consumers is yet to shift to this market.

According to ERSE (2020), there were 6.277.358 consumers of electricity in Portugal by the end of 2019. The liberalized market on continental Portugal represented 95% of the total consumption (5.243.352 customers), which accounted for an annual consumption estimated at more than 43.2 TWh, and 84% of the total number of consumers, which was more than 5.2 million customers. Liberalized market penetration was very significant on SME's, industrial and large consumers – parcel of the market where the liberalized market represented just short of 97% in number of consumers and more than 99% in total consumption –, being a little lower for domestic consumers, the parcel out of which only 83% (or 87% in aggregate consumption) were supplied by retailers in the liberalized market. Consumer market numbers were, in December 2019, as follows: 6.214.802 domestic customers, demanding 17.769 GWh of electricity; 37.144 SME's, accounting for 3.435 GWh of consumption; 25.022 industrial customers, responsible for 15.002 GWh of electricity consumption; and finally 390 large consumers, with needs of 9.492 GWh. These values represent the picture "as is" by the end of December 2019. Almost three out of every four gigawatt consumed in Portugal is due to industrial or domestic consumers, as their share in the market is 71.7%.

In particular for industrial consumers, the abovementioned 25.022 customers represent the whole set, regardless of the market they are associated with. In fact, out of that value, 24.419 customers were supplied in the liberalized market, and the remaining 603 were still associated with the regulated market, which accounts for 97.6% penetration of the liberalized market in terms of number of customers. Concerning the consumption levels, only 70 GWh were supplied in the regulated market, while the remaining 14.932 GWh were supplied in the liberalized market, which gives a percentage of 99.5% penetration to the liberalized market.

With the focus now on the supply side of the market, the same ERSE report pointed to a total of 28 different active retailers operating in the Portuguese liberalized market for this particular customer group. Given the attractiveness of the industrial parcel of the market – higher electricity requirements, higher individual value –, the market shares seem to be much better split between retailers than other customer groups.

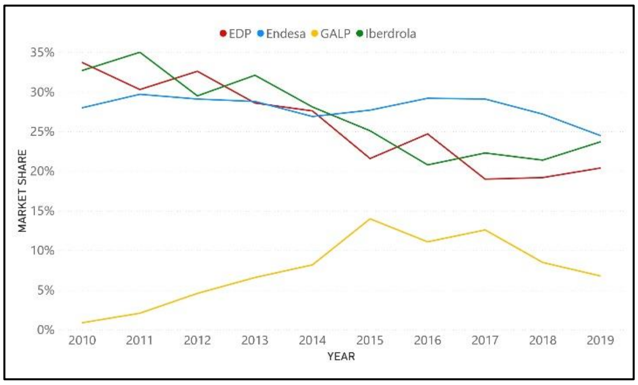
Figure 5. Market shares of retailers operating in the industrial segment in Portugal



Source: own elaboration based on ERSE (2020)

Endesa is the market leader for this segment of the market, while EDP Comercial trails in second place. In fact, the three biggest retailers of electricity in Portugal – EDP Comercial, Endesa and Iberdrola – control the majority of the market, being responsible for 68.6% of the consumption supply as of 2019. Much more competition is in place, as smaller players get to achieve significant shares of consumption, which is mirrored on the difference between the Herfindahl-Hirschman Index (HHI) as of 2019, which was 1.701, and the HHI from ten years before, which was about 3.030. In fact, according to the ERSE report, the industrial segment is a success case, being the segment that registers the lowest market concentration out of all customer groups. The evolution of market shares over the past 10 years for the four biggest retailers operating in the industrial segment is presented below:

Figure 6. Evolution of the market shares of top retailers operating in the industrial segment in Portugal



Source: own elaboration based on ERSE's monthly bulletins and annual reports on the electricity retail market

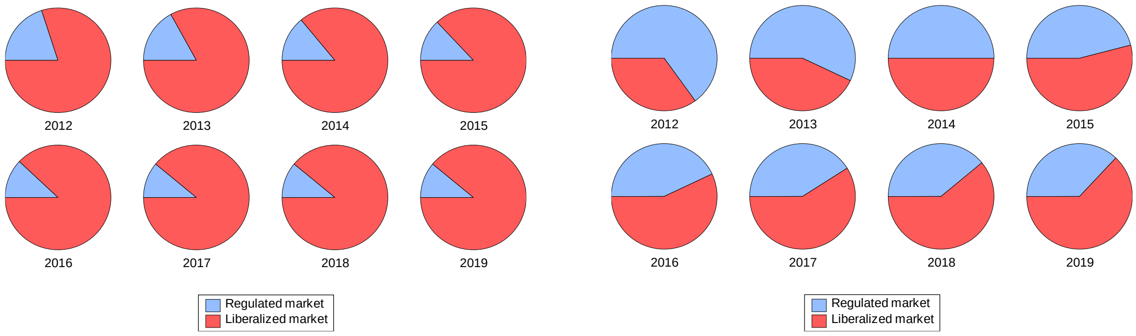
Not only do EDP Comercial, Endesa and Iberdrola control the majority of this segment's market, they have done so for quite a long time. Nevertheless, their aggregate market share was standing at 94.4% back in December 2010, lowering to the mentioned 68.6% in December 2019, which means that smaller players are entering the market and achieving significant shares of consumption.

4.2. State of the art in Spain

Similarly to Portugal, the Spanish introduction of liberalization on the electricity retail market is being conducted on a progressive mindset, currently with the coexistence of retail activity in a free competition regime and retail activity under regulation. By the end of 2019 there were still available 8 suppliers of last resort providing regulated tariffs to the consumers in low voltage that have not switched to the open market (CNMC, 2020).

The liberalized market situation since 2012 clearly shows that the liberalized market had already much more traction in Spain than it had in Portugal, regardless of the method – whether in terms of supplied electricity or in terms of number of consumers – used:

Figure 7. Evolution of the market share of the liberalized market in Spain (consumption and # of customers)



Source: own elaboration based on CNMC (2020)

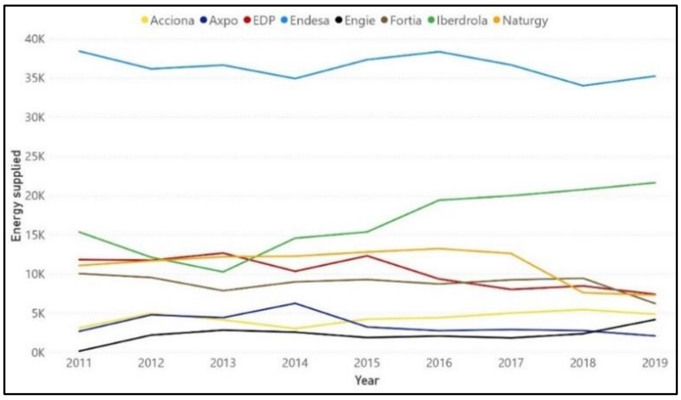
The penetration of the liberalized market was already of about 80% in 2012, which is much higher than the 55.7% registered in Portugal at the same time. By 2019, almost 9 out of every 10 GWh/year consumed in Spain were supplied by a competitive retailer operating in the liberalized market.

However, the scenario changes when taking into account the penetration of the liberalized market measured by the number of consumers, as seen below. Compared to the 11.7% seen on the Portuguese market, the 35% market share in 2012 seem much more significant. However, Portugal's quota for the liberalized market was registered at 82.7% of customers by 2019, which is a much bigger evolution than the Spanish one. Indeed, while low voltage consumers' market penetration in Portugal was of about 80%, for the Spanish side the value was close to 60%. Taking this into account, there is still a long path to walk before stating that the Spanish market is absolutely liberalized, as by 2019 more than one third of the consumers were supplied by the regulated market.

According to CNMC (2020), there were 29.546.187 consumers of electricity in Spain by the end of 2019. Naturally, the Spanish market is a much bigger market than the Portuguese one: total annual consumption of electricity was valued at 237.452 GWh. Demand structure was, in December 2019, as follows: 28.641.936 domestic customers, demanding 73.544 GWh of electricity; 880.105 SME's, accounting for 52.785 GWh of consumption; and finally 24.146 industrial customers, with needs of 111.123 GWh of electricity. Similarly to Portugal more than three quarters of the total volume of electricity consumed in the market are due to the industrial and domestic segments. In 2018 (since no data was found for 2019), only 59% of domestic consumers were being supplied by a liberalized retailer. In contrast, this value is 98% for SME consumers and 99% for industrial consumers, which explains why the market share of the liberalized market in terms of the number of consumers is around 63%: a significant share of domestic consumers – which represent 94.2% of the market – is yet to shift to a competitive retailer.

Focusing now on the supply side, CNMC (2020) report accounted 181 different retailers operating in the industrial segment in 2019. The evolution of supplied energy from the period 2011 to 2019 is as follows:

Figure 8. Evolution of the market shares of top retailers operating in the industrial segment in Spain



Source: own elaboration based on CNMC (2020)

The industrial segment represented 46% of the electricity consumed in Spain that year at a consumption volume more than twice the size of the Portuguese market as a whole. Liberalized market penetration is fully achieved at least since 2012. Between 2011 and 2017, the HHI decreased from 1.940 points to 1.757 points, even though Iberdrola has managed to double its market share between 2013 and 2019. Naturally, smaller players face difficulty in increasing service to this segment of the market, perhaps because the average consumption of a customer from this segment is about 4 GWh/year, which implies a large commercial structure to fulfil its needs.

Once again, as seen in Portugal, the introduction of the liberalized market has been a relevant contribution to lowering the levels of concentration on the commercialization activity.

4.3. Retail price formation in Portugal

With the market split into regulated and liberalized sides, it is necessary to create mechanisms that allow for the correct functioning of both markets. Consumers end up paying more than just the energy they consume, which is why it is fundamental to study the price structure and reasoning behind Portuguese and Spanish electricity systems.

To explain the Portuguese price formation process, let's consider ERSEFORMA (2021). ERSE is responsible for a number of procedures that promote the functioning of the market. In particular, regarding tariffs and pricing, ERSE is responsible for the approval of the rules, methodology and tariff values, as well as the promotion of efficiency and rationality on the activities of the regulated market in a clear, transparent, competitive and non-discriminatory way and guarantee that the costs necessary to meet all these goals and to the supply of electric energy are efficiently charged to consumers. Every three years, ERSE publishes a new "Regulamento Tarifário", a document that centralizes regulation parameters such as calculation methodologies. In between, every year, ERSE proposes a calculation of the tariffs and prices for the year based on predictions of demand, which must be approved by a council and published if so.

Regulated activities – to whom ERSE defines revenues that enable the companies that perform them to keep operating – include general technical operation of the system, transmission of electric energy, its distribution, the supplier switching operator's activity, electricity wholesale trading operation and its commercialization under a regulated market regime. There is a tariff for every regulated activity of the value chain. Translating this to the accounting sphere, there are traditionally three components in the customer's electricity bill: a network access tariff, the energy component and a taxes and other costs component. This is common to every consumer in Portugal, whether being supplied by the liberalized market or by the retail market, whether being a domestic or an industrial consumer, no matter the location.

Starting with the network access tariff, it represents the amount to compensate the infrastructure to transport electricity from generation to its supply and it comprises four components, which coincide with the first four regulated activities mentioned above: a global technical system operation tariff, an electricity transmission network tariff, an electricity distribution network tariff and the supplier switching operator tariff. The global technical system operation tariff, which is split into two parts: a first parcel that allows the recuperation of the costs of managing the electric system (received by the TSO) and a second parcel which enables the recuperation of the costs associated with energy policies, environmental and general economic interest and the costs for maintaining a contractual equilibrium with producers with power purchase agreements (PPA's). These costs are not defined by ERSE, as they are a matter of political decisions from the Portuguese government[3]. Most common costs are the ones that subsidize renewable production or the ones that promote tariff convergence between mainland Portugal and its archipelagos, Madeira and Azores. All these costs are reflected on the final consumer's electricity bill and are extremely relevant, as they represent, on average, more than half of the total value of the network access tariff as a whole.

Moving to the taxes and other costs component, these result of political decisions and are out of scope of the regulator's action. In Portugal, this component comprises a tax for DGEG, the audio-visual contribution tax, the special tax for the consumption of electricity and the value added tax (VAT).

The energy parcel of the bill is split into two tariffs, namely the energy tariff itself and the supply tariff, and it is due to the entity that supplies electricity to the consumer, which could be a retailer in the liberalized market or the supplier of last resort, for consumers in the regulated market.

4.4. Retail price formation in Spain

The Spanish price formation process[4] is very similar to the Portuguese one, as there are also three components of the electricity bill: the energy component, the access tariffs component and the taxes. These expenses are common to every consumer, no matter the market they are attached to (regulated or liberalized).

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[3] The rationale behind these Costs of General Economic Interest (CIEG) is explained in article 93rd of ERSE's "Regulamento tarifário" for 2021

[4] This section is based on https://www.energiaysociedad.es/manenergia/7-1-los-peajes-de-acceso-y-cargos-estructura-costes-y-liquidacion-de-los-ingresos/

Starting with the access tariffs, similarly to Portugal they are used to compensate the infrastructure of transmission and distribution, since the European directives set the third-party access principle. This means that they are set to cover the costs of expanding or maintaining the networks. Not only do they include these costs, but they also cover the electricity tariff deficit, the funding of RECORE generation (renewable, cogeneration and residue), the extra-peninsular compensations, which allow for a consumer outside of continental Spain to pay the same for the electricity consumed, among other costs. These are defined every year by the Spanish government according to a methodology defined by CNMC.

Secondly, the taxes component is subject to political decisions and the regulator has no control of the value output. In Spain, these include the value added tax (VAT) and a tax on electricity usage.

Finally, the energy component of the bill is defined by each retailer, alongside with the margin for commercialization, which is the remuneration of the retailer as it supplies a final consumer, in the case of a customer attached to the liberalized market. In the case of a consumer supplied by a supplier of last resort, the price to pay is set everyday and is named "Precio Voluntario para el Pequeño Consumidor" (PVPC). In the case of a vulnerable consumer, this tariff is applied with 25% discount.

It is important to mention the cost drivers behind all the mentioned costs above, which are common to both countries: most of them vary according to power, active energy and reactive energy, meaning that they are split into billing variables that are associated with the costs actually caused by each consumer.

The energy component of the bill is where the final price of electricity might change depending on the marketplace a given consumer supplies itself, as the network access tariffs and the taxes components are universally applied. In fact, if the consumer is being supplied by a retailer on the liberalized market, then the energy and supply tariffs are decided by the retailer, as each supplier defines freely the value for both these tariffs, in competition with other retailers. On the other hand, if the consumer is being supplied by the regulated supplier, i.e. the supplier of last resort, regulated energy tariffs defined by ERSE and CNMC apply, in order to guarantee a return on the activity of electricity wholesale trading, as well as regulated commercialization tariffs, that apply in order to compensate for the services and commercial structure behind this retailer's sales.

5. Problem formulation and econometric model

The goal intended with the presentation of all the information stated so far is to guide the reader to the following argument: Portuguese and Spanish electricity markets are similar. Apart from the clear divergence in size, their market operator is the same, the structure of the retail market is very similar – often with the same players leading a segment – and the phenomenon of market splitting seldom occurs, or when it occurs, differences are often residual, as we will see. Adding to this, final price at the retail level is constructed with the same three large components. Could it be feasible to consider that price dynamics at the retail level show the opposite scenario, that is, a considerable divergence in pricing?

This chapter will portray an empirical analysis on electricity retail price dynamics for industrial consumers according to the most representative consumption band of both countries. The goal behind this analysis is to compare a dataset of monthly prices from 2010 to 2019 and understand what variables have significant impact on prices, i.e. what are the drivers of the retail prices in each country.

5.1. Price behaviour analysis

Before conducting an in-depth analysis of the model to estimate, it is necessary to start with some initial considerations and conceptualizations, as well as a statistical analysis of the prices gathered for this exercise. The data collected for pricing is the same data that was treated and studied by Rademakers et al. (2020). This dataset contains 240 observations, split in 120 prices for each month of the scope 2010 to 2019 for both Portugal and Spain[5]. Its monthly data is a combination of Eurostat's biannual electricity price statistics (developed in collaboration with every European country, these statistics contain pricing data at the retail level every semester) and monthly Harmonised Indices of Consumer Prices (HICP).

Two important topics to mention beforehand: the collected data on prices excludes VAT and other recoverable taxes and levies. This way, if there are differences to register, they must occur at the access tariff level or at the energy component level. Another important topic to cover is the concept of Eurostat's consumption bands. These bands are a method

[5] This data is openly available on a dashboard in the European Commission's website by following the path Energy > Data and analysis > Energy prices and costs in Europe > Dashboard for energy prices in the EU and main trading partners.

for applying segmentation to the industry market according to the consumption of a given company, and range between IA (annual consumption below 20 MWh) and IG (annual consumption above 150 000 MWh). The prices considered in the mentioned study, and therefore for this exercise as well, are for the most representative consumption band in each country. For Portugal, the focal consumption band is IB – customers consuming 20 MWh or more but less than 500 MWh per annum – while for Spain the focal consumption band is ID – customers consuming 2.000 MWh or more but less than 20 000 MWh. Naturally, given the clear divergence in consumption volumes, the results reached can be biased. However, no data on monthly prices was available to more consumption bands. Below, the collected monthly prices per MWh are displayed for the time span under analysis. This information is complemented by the table 3, on which a descriptive statistic analysis is conducted:

Figure 9. Retail prices for industrial consumers of the most representative consumption band in Portugal and Spain

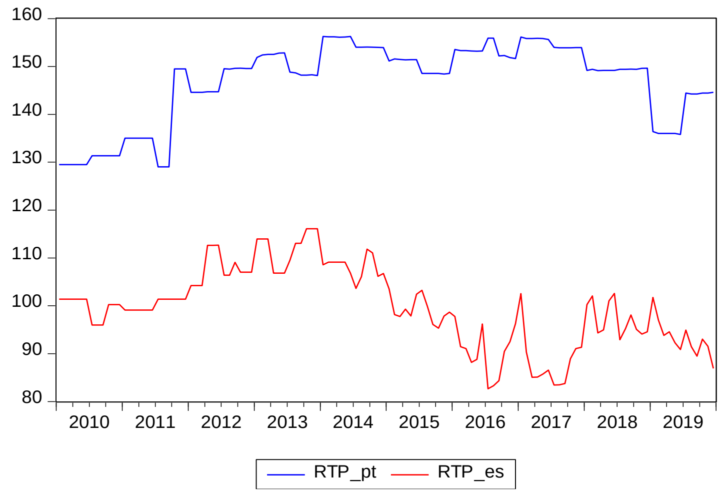

Table 3. Descriptive statistics associated with the retail prices pictured

Variable	Year	Portugal				Spain			
		Average	Maximum	Minimum	Standard deviation	Average	Maximum	Minimum	Standard deviation
Electricity retail price for industrial consumers	2010	130.42	131.34	129.49	0.92	99.74	101.38	95.97	2.23
	2011	137.15	149.49	129.03	7.54	100.25	101.39	99.11	1.14
	2012	147.12	149.65	144.59	2.46	107.80	112.68	104.23	3.11
	2013	150.44	152.85	148.13	2.08	112.19	116.08	106.83	3.53
	2014	155.10	156.29	153.93	1.10	108.11	111.82	103.65	2.20
	2015	149.97	151.60	148.44	1.44	99.17	103.52	95.32	2.54
	2016	153.30	155.91	151.67	1.31	90.25	97.78	82.65	4.85
	2017	154.90	156.14	153.92	0.97	88.11	102.52	83.46	5.17
	2018	149.35	149.65	149.12	0.18	97.10	102.58	92.93	3.34
	2019	140.22	144.59	135.83	4.18	93.13	101.76	86.91	3.63
	Total	**146.80**	**156.29**	**129.03**	**8.39**	**99.59**	**116.08**	**82.65**	**8.25**

Sources: own elaboration based on the monthly price dataset considered in Rademakers et al. (2020)

One initial conclusion stands clear with the single observation of figure 9: there are clear and very significant price differences between both countries. In fact, looking at the table above we can quantify the differences spotted in the visual display of the data and validate this first hypothesis. On average, the retail price of electricity for the consumption band with the highest share of the market is 47.21€/MWh higher in Portugal than it is in Spain (this value corresponds to the difference between total averages for both countries). Not only Portuguese industries face this surely impactful gap, but the lowest price in Portugal is well above the maximum price in Spain. Moreover, the overall volatility of prices, measured by the standard deviation of the sample, is higher in Portugal than it is in Spain, which could lead to less predictability of expenditures at the firm level.

Notwithstanding the consumption band differences, which very likely play a pivotal role in explaining these results, this could be caused by other factors as well. Let's notice, for example, that between 2014 and 2016, the price range in Portugal seems to be very stable between 148.44€ - 156.29€ per MWh while the prices in Spain seem to be dropping with prices ranging between 82.65€ - 111.82€ per MWh. Given the conditions upon which these prices are originated, such divergence seems to be an uncanny phenomenon to occur and most likely the differences in the consumption levels do not explain it. Why should the price be dropping so considerably in Spain while stabilizing in Portugal? Why should markets apparently so similar have such price differences? What variables could be driving these prices oftentimes in opposite direction, knowing that their market operator is the same, prices are formed under the same methodology and even key players are the same? How can this damage the competitiveness of the identified Portuguese industries?

5.2. Variables of the econometric model to estimate

Literature is surprisingly scarce on the variables that contribute to the formation of the retail price of electricity. Therefore, several variables will be tested in the econometric model proposed below, some of which with oftentimes contradictory results in the literature.

The first set of variables proposed are related to the share of renewable energy sources in the production mix of the countries. On the one hand, it is broadly accepted that the penetration of renewable sources of energy in the market pushes down the prices of electricity at the wholesale level. This conclusion is backed by Ballester and Furió (2015) for the Spanish day ahead market and Saraiva and Gonçalves (2016), for instance, the last of which claiming that the average price of the day ahead market in the Iberian electricity market would increase from 43.37 €/MWh to 82.63 €/MWh if special regime generation from both Portugal and Spain was not considered. Since electricity markets are traditionally marginalist markets, meaning that the settlement market price tends to be equal to the marginal cost of the generator with the lowest bid, and that renewable technologies have very low marginal costs, the highest their penetration in the generation market, the lowest the price of that market tends to be. This is the "merit-order effect". On the other hand, the impact that renewable production has on end-user price is unclear and inconclusive. In fact, while Sáenz de Miera, del Río González, and Vizcaíno (2008) conclude that there is a net reduction in retail prices following an increase in wind generation in Spain, while Costa-Campi and Trujillo-Baute (2015) reach the opposite conclusion.

Following all these studies and the uncertainty behind the impact of this variable, the econometric model to be considered will include four ratios: the % of electricity generated by solar, wind, hydro and nuclear technologies on the total generation of electricity. Hydro and nuclear are considered as well, as they have impact on the day ahead prices of MIBEL, as shown by Mourão (2013).

Another variable to be considered in the model is the market concentration, measured here by the sum of the market shares of the 5 biggest players operating in the market. The market concentration variable was expressed in many different indicators in the literature, but the work of Moreno, López, and García-Álvarez (2012) and later by Oosthuizen, Inglesi-Lotz, and Thopil (2022) obtained an unexpected result: ceteris paribus, an increase in electricity market concentration has led to a decrease in prices at the retail level. We will test this hypothesis as well.

According to Fotouhi Ghazvini, Ramos, Soares, Vale, and Castro (2016), the success of deregulation policies in a retail market of electricity could be measured by the degree to which end-user prices follow the variations of prices at the wholesale level. In order to measure this connection, the econometric model will consider the standard variation of prices both at the spot market and at the derivatives market.

Predictably, one of the key variables with impact on retail prices is the network access tariffs. This variable will be considered as an independent variable. Lastly, the final two variables seek to understand the share of consumption that is covered by the day ahead market traded volumes and the derivatives market traded volumes, in order to take conclusions on if the wholesale buying strategy of a country has impact on the retail prices.

Thus, a linear regression model is proposed with the following equation:

$$
\begin{aligned}
Rtp_{i,t} = \beta_1 + \beta_2 Sol_{i,t} + \beta_3 Wnd_{i,t} + \beta_4 Hyd_{i,t} + \beta_5 Dum_{i,t} \times Nuc_{i,t} + \beta_6 CR5_{i,t} \\
+ \beta_7 Std\_OMIE_{i,t} + \beta_8 Std\_OMIP_{i,t} + \beta_9 Nat_{i,t} + \beta_{10} Ner_{i,t} + \beta_{11} Ibe_{i,t} + u_{i,t}
\end{aligned}
$$

where:

- $Rtp_{i,t}$ is the retail price of electricity for industrial consumers for the most representative consumption band of country i in month t
- $Sol_{i,t}$ is the % of the total electricity generated in month t in country i that was generated from solar photovoltaic technology
- $Wnd_{i,t}$ is the % of the total electricity generated in month t in country i that was generated from wind technology
- $Hyd_{i,t}$ is the % of the total electricity generated in month t in country i that was generated from hydro technology
- $Dum_{i,t}$ is a dummy variable that takes the value of 0 for i = Portugal and the value of 1 for i = Spain, in month t
- $Nuc_{i,t}$ is the % of the total electricity generated in month t in country i that was generated from nuclear technology
- $CR5_{i,t}$ is the concentration ratio of the market at 5 players in month t in country i (annual value, assumed to be constant over the year)
- $Std\_OMIE_{i,t}$ is the standard deviation of the daily price of the spot market (OMIE) in country i and in month t
- $Std\_OMIP_{i,t}$ is the standard deviation of the daily price of the derivatives market (OMIP), here represented by the first annual contract listed in each year, in country i and in month t
- $NAT_{i,t}$ is the average value for the network access tariffs in month t and in country i (annual value, assumed to be constant over the year)
- $Ner_{i,t}$ is the ratio of the negotiated electricity in the day-ahead spot market in country i and in month t, divided by the consumption of electricity of the same country for the same month
- $Ibe_{i,t}$ is the ratio of the negotiated electricity in the derivatives market at the MIBEL level (Portugal + Spain) in month t, divided by the consumption of electricity for the same month (annual value, assumed to be constant over the year)
- $u_{i,t}$ is the error term

Before estimating the model, it might be relevant to look at each of these variables in detail, explaining data sources and studying their evolution over the 10 years considered.

Regarding the variable $Sol_{i,t}$ (the ratio of solar PV generated electricity[6] penetration), the table 9 in annex demonstrates that Portugal and Spain have invested strongly in solar photovoltaic parks. It is no wonder that the share of solar photovoltaic production in the total electricity produced over the month is growing year by year. Portugal started this observation period with less than 0.5% ratio, but ended with more than 2.2%, growing at a whopping 400% between start and finish lines of the considered period. As for Spain, the starting point in 2010 is the same as the Portuguese ending point in 2019, which is 2.28%, and the country reaches 2019 with 3.61%. On average, solar photovoltaic penetration is 1.77% higher in Spain than it is in Portugal.

Concerning the variable $Wnd_{i,t}$ (the ratio of wind generated electricity[7] penetration), the table 10 in annex demonstrates that Portugal shows better metrics than Spain. These annual statistics show that wind generated electricity has been a priority for Portugal: the average value for 2019 represents a 53.52% growth from the value registered for 2010. As for Spain, which saw about 36.3% growth during the 10 years, the average value for the whole period considered is 18.82%, about 3.5% less than the average for Portugal.

When it comes to the variable $Hyd_{i,t}$ (the ratio of hydro generated electricity[8] penetration), the table 11 in annex proves that hydro technology seems to be losing pace. On average, the contribution of this technology dropped around 80% in Portugal and about 52.6% in Spain during the period considered. Nonetheless, this source represented a very significant share in Portugal, at an average value of 21.43%, which is 9.29% more relevant that the share this source represents in the Spanish generation system. Worthy to mention, in Portugal hydro generated electricity accounted for an average value of more than 50% of all generated electricity for two times during the 10 considered years.

The ratio of nuclear generated electricity[9] penetration is expressed in the variable $Nuc_{i,t}$ and its annual results are shown in table in annex. Nuclear production does not exist in Portugal, as there is no installed capacity to produce energy from this source. Hence, the statistic measures are only presented to Spain in table 12. Values are very steady, without much volatility and since this technology represents more than 20% of the final electricity output, we can say that nuclear generation plays a pivotal role and is essential to the functioning of the Spanish market, as at least it brings stabilization of supply at low marginal cost.

[6] Solar generation data was collected from REN and REE, and so were the monthly production values
[7] Wind generation data was collected from REN and REE, and so were the monthly production values
[8] Hydro generation data was collected from REN and REE, and so were the monthly production values
[9] Nuclear generation data was collected from REE, and so were the monthly production values

It is important to consider this technology as a possible driver to the price of electricity as nuclear production has a very small marginal cost of production. This means that the market pool price will be pushed down due to the "merit-order" effect, and since this technology does not exist in Portugal, it is conceivable that it might have impact on the price gap between the Portuguese and the Spanish market.

Concerning the $CR5_{i,t}$ (market concentration on the liberalized retail market), the ratio is the result of the sum of the values of the market shares of the 5 biggest players in the market[10]. It measures the level of market concentration, which can have impact on end-user prices as it gives companies more power to negotiate plus more power to increase commercialization margins, for instance. This value ranges from 0% to 100%, so that the closer a CR5 ratio is to 100%, the more concentrated the market is. As shown in the table 13 in annex, the Portuguese retail market is historically more concentrated than the Spanish one, which is confirmed by the values of CR5 captured over the 10 years considered. On average, the 5 biggest players in Portugal held a 92% market share, while in Spain only 79% could be attributed to them. As seen above with the Herfindahl-Hirschman Index, which also measures the market concentration, annual concentration values are dropping, with Portugal decreasing 20% and Spain decreasing 18.18%.

The variable $Std\_OMIE_{i,t}$ results from the spot market price dynamics[11] in both countries, which originated, from time to time, different hourly prices for each country, the so-called market splitting phenomenon. The values represent statistical calculations on the daily prices in the spot market for the PTEL Base Index and the SPEL Base Index products, respectively for Portugal and Spain. The table 14 in annex demonstrates that all metrics considered appear to be very similar, notwithstanding the fact that during the 3652 daily sessions registered, market splitting occurred in 1431 daily sessions. On average, the price for Portugal was less volatile than in Spain.

Similarly, the variable $Std\_OMIP_{i,t}$ expresses the monthly standard deviation of the futures market price[12]. The goal with the introduction of this variable is to address the derivatives market performance. Since this market offers a variety of products ranging from futures to options, for the purpose of this variable was considered one of the most liquid

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[10] These market shares were available on CNMC's "informe de supervision del mercado minorista de electricidad" and ERSE's "Relatório Anual sobre os Mercados Retalhistas de Eletricidade e Gás Natural"
[11] Daily spot market prices were extracted from OMIP's webpage
[12] Daily futures prices were manually computed from FTB or FPB YR10 to YR19, according to the daily prices in OMIP's webpage

products: futures contracts. For simplification purposes, the product considered was SPEL Base Futures and PTEL Base Futures with annual maturity, once again for liquidity purposes, as the traded energy volumes are representative, only similar to the energy traded in quarterly products. In particular, since futures' trading period could be years apart from the delivery, as opposed to the spot market, where prices are relatable to an amount of energy to be delivered the day after negotiation, it was assumed that the standard deviations here considered would be of the product FTB YR t. This means that the standard deviation below presented for 2011, for example, are actually an average of the monthly standard deviations of the product FTB YR-10 from January to December 2010. This period – the year right before maturity – is typically where most of the negotiations take place. The table 15 in annex shows that market splitting is much more common in futures contracts and that on average, Portuguese futures are less volatile than Spanish futures. It is critical to consider this variable in the model, as retailers in MIBEL buy electricity at the wholesale level from at least three options: spot market, derivatives market and via bilateral contracts. It is hard to measure the acquisition cost implied in bilateral contracts, as we do not have information on the economic conditions settled in the bilateral agreement whether of physical or financial delivery. However, the OTC market's reference price is typically the derivatives market, which makes it critical to consider this as a variable with possible impact on price.

Network access tariffs[13] are expressed in the variable $NAT_{i,t}$ and typically depend on the voltage level, the contracted power and the time-of-use options, as well as the period of the year that the electricity was consumed in. The table 16 in annex presents average values of network access tariffs according to the two consumption bands considered. A clear highlight to the fact that Portuguese access tariffs are generally higher than the ones seen in Spain. Due to lack of data, it was not possible to dig deeper on the components of the network access tariffs of both countries.

Regarding the variable $Ner_{i,t}$ (the % of the monthly demand of a country which is covered by the traded volumes of electricity in the day-ahead spot market for that same country)[14], the table 17 in annex demonstrates that Portugal's average ratio is much higher than the Spanish one. point to a scenario of full coverage in Portugal, oftentimes surpassing the 100% barrier, meaning that the negotiated electricity in the spot market in a particular

13 Extracted from Eurostat's "Electricity prices components for non-household consumers - annual data (from 2007 onwards)" dataset

14 The monthly demand information was collected from REN and REE, while the negotiated volumes in OMIE sourced from OMIE's webpage, REE's REData and CMVM's monthly bulletins

month was more than enough to fulfil demand levels. As for Spain, the scenario is different, as the ratio sits at an average around the bottom 70% consistently.

Lastly, $Ibe_{i,t}$ is a variable common to both countries. The ratio is very similar to the previous one, although instead of considering monthly volumes of negotiated electricity, here are considered annual volumes negotiated in OMIP[15], regardless of the contract maturity, and the consumption is now the consumption of electricity at the Iberian level, not just each country. Due to lack of data for both countries, this variable is assumed to be constant over the year and common to Portugal and Spain. The table 18 in annex shows that the negotiated volumes in the derivatives market peaked in 2014 and dropped since then. An important highlight here is that these volumes negotiated in OMIP can have a sheer risk management function, as contracts with financial delivery are also included here.

5.3 Model estimation

Although the model equation is showing each variable as if a panel data regression – using cross-sectional and time series data – was about to be made, the fact is that we will estimate the coefficients for both countries and conclude on what variables have driven retail prices over the considered period for each country, using the software EViews 10.

5.3.1 Model estimation for Portugal

The initial OLS estimation of the model for the Portuguese dataset was completed with 114 observations, from month 2010M7 to 2019M12. During the first six months of 2009 there was no activity of the futures contract FPB YR10, which originated a truncation of 6 observations. Considering the heterogeneity of the variables that compose the model, it was necessary to test the hypothesis of heteroskedasticity regarding the variation of the error term. In order to do that, it was conducted a White test which indicated that the nR^2 (85.3897) exceeded the critical value of the chi-square table at the 5% level for 54 degrees of freedom (72.1532), suggesting a strong evidence of heteroskedasticity. As a consequence, in order to obtain more robust estimators, a correction based on White method was used, resulting in the following output table:

[15] Data from the OMIP Annual Reports 2010-2019, available openly in OMIP's webpage

Table 4. Model estimation output for Portugal

Dependent Variable: RTP
Method: Least Squares
Date: 09/08/21 Time: 03:41
Sample (adjusted): 2010M07 2019M12
Included observations: 114 after adjustments
White-Hinkley (HC1) heteroskedasticity consistent standard errors and covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.134055	0.013108	10.22660	0.0000
SOL	-0.195487	0.092588	-2.111356	0.0371
WND	-0.017722	0.008640	-2.051180	0.0428
HYD	-0.007220	0.003473	-2.078867	0.0401
CR5	-0.025571	0.009671	-2.643959	0.0095
STD_OMIE	0.000190	0.000148	1.287479	0.2008
STD_OMIP	-0.000951	0.001347	-0.706023	0.4818
NAT	0.411090	0.063578	6.465873	0.0000
NER	0.022900	0.006379	3.589805	0.0005
IBE	0.042453	0.016763	2.532553	0.0128

R-squared	0.705997	Mean dependent var	0.147707
Adjusted R-squared	0.680555	S.D. dependent var	0.007611
S.E. of regression	0.004302	Akaike info criterion	-7.975981
Sum squared resid	0.001924	Schwarz criterion	-7.735963
Log likelihood	464.6309	Hannan-Quinn criter.	-7.878571
F-statistic	27.74867	Durbin-Watson stat	0.722925
Prob(F-statistic)	0.000000	Wald F-statistic	28.85015
Prob(Wald F-statistic)	0.000000		

At first glance, we can see that all independent variables apart from Std_OMIE and Std_OMIP appear to be statistically significant at the 5% level and that the regression is globally significant as the F-statistic is 0.

The variables related with renewable production all show a p-value below 0.05 and a negative coefficient, indicating that the higher the generation of electricity via solar, wind or hydro technologies over the total electricity production of a given month, the lower is the end-user price. This validates the work of Sáenz de Miera et al. (2008). While the standard deviations of the prices in the spot and derivatives market does not seem to be relevant, the traded volumes of electricity in these markets are: the bigger the ratio of NER or IBE, that is, the higher the coverage of demand by the spot and derivatives market, the more expensive the price. Similarly significant is the value of NAT, which appears to explain largely the evolution of the retail price.

As for the impact of the concentration ratio CR5, here portrayed as statistically significant but with a negative coefficient, indicating that the more concentrated the market is, the lower the price tends to be, this is in line with Moreno et al. (2012) and Oosthuizen et al.

(2022). However, let's notice that the CR5 values for 2010-2012 were 1, indicating a fully concentrated market on 5 players, and have been dropping ever since, though the price does not follow the same tendency. In fact, notwithstanding the lower market concentration, the retail price for this consumption band of the Portuguese market has not been following this trend.

5.3.2 Model estimation for Spain

This same exercise was done to the Spanish market as well. The observations were complete at n=120, ranging from month 2010M1 to 2019M12. Once again the model was estimated via the ordinary least squares method and subject to the White test to access the possibility of heteroskedasticity. Similarly to the Portuguese case, the associated test statistic given by nR^2 (88.9012) surpassed the critical value of the chi-square table at the 5% level for 65 degrees of freedom (84.8206), suggesting a strong evidence of heteroskedasticity. In order to obtain more robust estimators, the model was estimated once again corrected by the White method, which resulted in the following output table:

Table 5. Model estimation output for Spain

Dependent Variable: RTP
Method: Least Squares
Date: 09/08/21 Time: 04:14
Sample: 2010M01 2019M12
Included observations: 120
White-Hinkley (HC1) heteroskedasticity consistent standard errors and covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.159346	0.018218	8.746571	0.0000
SOL	-0.137845	0.068126	-2.023375	0.0455
WND	-0.037537	0.016039	-2.340326	0.0211
HYD	-0.000111	0.010682	-0.010428	0.9917
NUC	-0.043894	0.022362	-1.962918	0.0522
CR5	-0.058707	0.014350	-4.091184	0.0001
STD_OMIE	0.000570	0.000178	3.204177	0.0018
STD_OMIP	0.001056	0.000835	1.265328	0.2085
NAT	0.705856	0.270634	2.608153	0.0104
NER	-0.025941	0.011554	-2.245297	0.0268
IBE	0.110135	0.016947	6.498842	0.0000

R-squared	0.629288	Mean dependent var	0.099585
Adjusted R-squared	0.595277	S.D. dependent var	0.008282
S.E. of regression	0.005269	Akaike info criterion	-7.566721
Sum squared resid	0.003026	Schwarz criterion	-7.311201
Log likelihood	465.0033	Hannan-Quinn criter.	-7.462953
F-statistic	18.50286	Durbin-Watson stat	0.803411
Prob(F-statistic)	0.000000	Wald F-statistic	22.99344

Prob(Wald F-statistic)	0.000000

Out of the 10 explanatory variables tested, only 3 came out as non-significant at the 5% level. In fact, by looking at the p-value of HYD, NUC and STD_OMIP, we can see that these variables do not have a relevant causal relationship with the Spanish retail price. Once again, the regression is globally significant as the F-statistic is 0.

Breaking down the results by groups of variables, we can see that RTP in Spain is impacted by renewable production from solar and wind technologies. As the coefficient associated with these variables is negative, the rational is the same as explained for Portugal: the higher the production of electricity from these renewable sources over the total production of electricity in a given month, the lower the price tends to be. Another group of variables that seems to have a relevant impact on the price is the volatility of the spot market price – here mirrored in Std_OMIE – and the coverage that the electricity negotiated in this market has on the total electricity consumption of the country. Both variables are significant, but impact the price in opposite directions: while Std_OMIE pushes prices up as the market becomes more volatile, NER pushes prices down as the traded volumes of electricity in the spot market over the total country consumption for the month ratio increases, which did not occur in Portugal. Regarding the traded volumes in the derivatives market, the rational is that the larger the share of the Iberian consumption traded in this market, the higher the price will be. Finally, the network access tariffs seem to explain a large share of the evolution of the retail market price in Spain as well, as the p-value indicates significancy and the coefficient is the highest among all other variables.

A last word to the situation previously seen in Portugal that occurs for the Spanish market as well. The negative coefficient value associated with this variable is against the economic principles of perfect competition, indicating that the more concentrated the market is, the lower the price tends to be.

6. Profiling

After understanding what drives the retail prices of electricity in Portugal and Spain, it is important to explore which particular industries are more exposed to these price dynamics. The definition of the target industries will be made through a mapping of four industry characteristics:

a) Industry export intensity ratio
b) Average number of companies
c) Industry electricity expenditures on production ratio
d) Industry electricity expenditures on total energy costs ratio

The European Commission identifies several industry divisions according to a statistical classification of economic activities method named NACE Rev. 2, where manufacturing industries are attached to section C of this economic activity classification method, further split into 24 divisions according to the industry's main output. For the purpose of this investigation, data was collected for the industries contained in section C, which comprises divisions 10 to 33. NACE Rev. 2 is mirrored under the CAE Rev. 3 and under the CNAE 2009 economic activity classification for Portugal and Spain, respectively. The table 6 provides information on the data sources used to calculate each of the mentioned indicators:

Table 6. Data sources regarding the four industry characteristics to study

Indicator	Country	Component	Source
Industry export intensity	PT	Industry exported sales	Eurostat's Trade by NACE Rev. 2 activity sector (optional table) dataset
	PT	Industry volume of sales	INE's Volume de negócios (€) das empresas por Localização geográfica (NUTS - 2013) e Atividade económica (Subclasse - CAE Rev. 3); Anual database
	ES	Industry exported sales	Eurostat's Trade by NACE Rev. 2 activity sector (optional table) dataset
	ES	Industry volume of sales	INE's Principales magnitudes según actividad principal (CNAE-2009 a 1, 2, 3 y 4 dígitos) database
Average number of companies	PT	Average number of companies	INE's Empresas (N.º) por Atividade económica (Divisão - CAE Rev. 3) e Escalão de pessoal remunerado; Anual
	ES	Average number of companies	INE's Principales magnitudes según actividad principal (CNAE-2009 a 1, 2, 3 y 4 dígitos) database
Industry electricity expenditures on production ratio	PT	Industry electricity expenditures	SABI - sum of the detailed component "Electricity", after filtering the CAE Rev. 3 (two-digit) from 10 to 33
	PT	Industry production value	INE's Produção (€) das Empresas por Localização geográfica (NUTS - 2013) e Atividade económica (Subclasse - CAE Rev. 3); Anual
	ES	Industry electricity expenditures	INE's Consumos energéticos by año, actividad principal (CNAE-2009 a 1, 2 y 3 dígitos) and producto consumido, filter "electricidad"
	ES	Industry production value	INE's Principales magnitudes según actividad principal (CNAE-2009 a 1, 2, 3 y 4 dígitos) database
Industry electricity expenditures on total energy costs ratio	PT	Industry electricity expenditures	SABI - sum of the detailed component "Electricity", after filtering the CAE Rev. 3 (two-digit) from 10 to 33
	PT	Industry total energy costs	SABI - sum of the energy costs, after filtering the CAE Rev. 3 (two-digit) from 10 to 33
	ES	Industry electricity expenditures	INE's Consumos energéticos by año, actividad principal (CNAE-2009 a 1, 2 y 3 dígitos) and producto consumido, filter "electricidad"
	ES	Industry total energy costs	INE's Consumos energéticos by año, actividad principal (CNAE-2009 a 1, 2 y 3 dígitos) and producto consumido, filter "total consumos energéticos"

As seen above, several data sources were used to enable the calculations that are about to be made. In general, four big databases were used: Eurostat, which organizes industries according to the NACE Rev. 2 codes; INE – Instituto Nacional de Estatística, the Portuguese statistic responsible entity, which organizes industries according to CAE Rev. 3 codes; INE – Instituto Nacional de Estadística, the Spanish statistic responsible entity, which organizes industries according to CNAE 2009 codes; and finally SABI – Sistema de Análise de Balanços Ibéricos, a comprehensive database with a very large coverage of the Portuguese and Spanish economic activity (for the purpose of this document, only Portuguese data was considered), granting access to company financials. It is important to clarify that NACE Rev. 2, CAE Rev. 3 and CNAE 2009 codes are all comparable, given that for the purpose of this document, only the first two digits of each of these economic activity classification codes will be used. Activity sectors 12 (manufacture of tobacco products) and 19 (manufacture of coke and refined petroleum products) will not be considered due to statistical confidentiality. The industry codes are in table 19 in annex.

6.1 Industry export intensity ratio

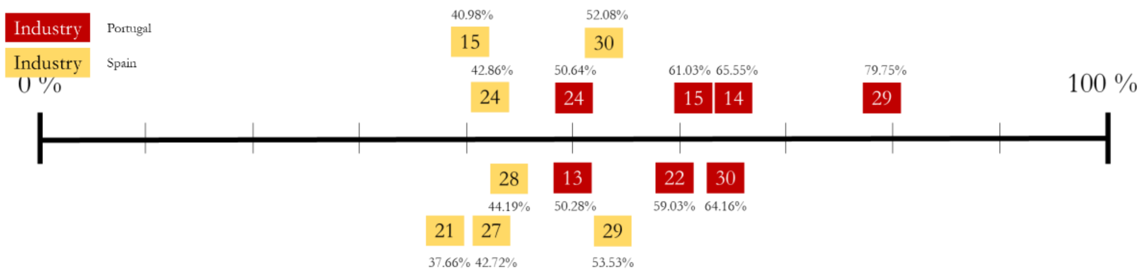
The approach will begin with an identification of the most export-intensive industries, through the calculation of the following ratio:

$$Industry\ export\ intensity = \frac{Industry\ exported\ sales}{Industry\ volume\ of\ sales} \times 100$$

The purpose behind the calculation of this ratio is to understand the weight that exported goods have in the total volume of sales of a given industry, i.e. how much (in %) of the sales of the a given economic activity is generated by its external trades.

The identified Eurostat's dataset used for this ratio breaks down the international trade flows – export monetary flows in particular for this exercise – by country on a yearly basis. Most recent data is from 2019. Spanish exports by NACE activity dataset was complete. However, the Portuguese dataset was incomplete and thus approximated values were used from Instituto Nacional de Estatística (2019), which quantifies the same information based on approximated values. The resulting values are shown in tables 20 and 21. The figure below highlights the top 7 "export-to-volume of sales" industries in 2019:

Figure 10. Industry export intensity ratio calculations



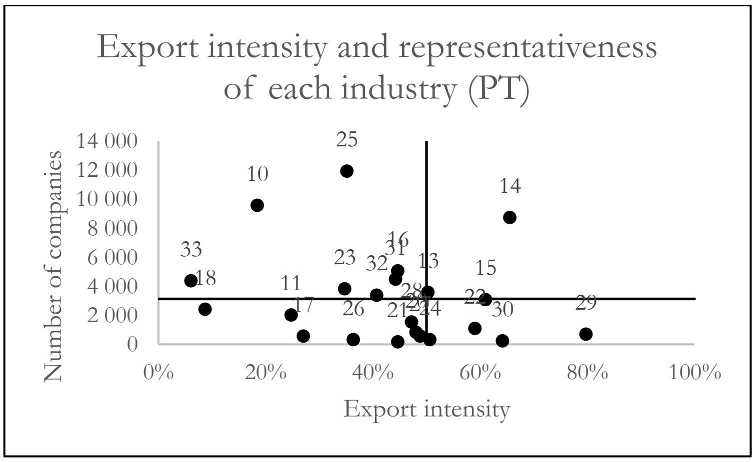
Source: own elaboration

Activity sector no. 29 – manufacture of motor vehicles, trailers and semi-trailers – is a winner in terms of export intensity for both countries, since on average close to 80% of the turnover of the companies from this industry in Portugal is due to export flows, a value that is around 53% for the Spanish side.

In general, Portuguese industries tend to be more export oriented than Spanish ones: the average export intensity ratio considering all industries' exported sales and turnover is of 43.59% for Portugal and 32.60% for Spain, which means that, on average, Portuguese manufacturing industries export close to 11% more than Spanish manufacturing industries.

6.2 Average number of companies

Figure 11. Data crossing from the first two industry characteristics for Portugal



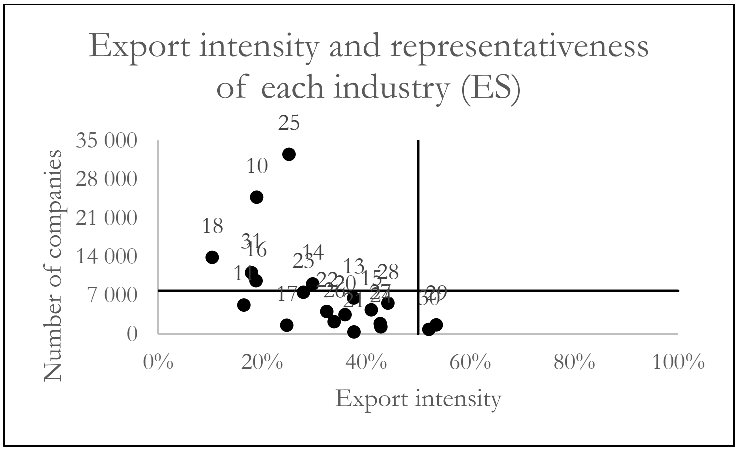
Source: own elaboration

Undoubtedly, the previous ratio is of very significant importance. However, we must factor in the representativeness of each industry. In fact, a given division might be very export-oriented, but with low representativeness in terms of number of companies and volume of sales. These values can be found in the table 22 in annex. Figure 11 associates each Portuguese industry to a pair (export intensity, number of companies) according to data from 2019 from the INE of the country.

The vertical line represents a ratio of 50% export intensity, a situation that means that the total volume of sales of an industry is split equally between internal markets and external markets. As for the horizontal line, it represents the average number of companies in the manufacturing industry as a whole.

Portuguese industry no. 14 – manufacture of wearing apparel – is positioned in the top right quadrant, which means that the number of companies in this industry is relevant (above average) and that it sells more than half of its sales to external markets. Even though the volume of sales per company is not the highest or among the highest, it is a relevant industry to the Portuguese economy and its external performance. Just touching the horizontal and vertical lines are activity codes no. 15 – manufacture of leather and related products – and no. 13 – manufacture of textiles – respectively, which indicates that they are very close to the top right quadrant, where the number of companies is above average and the industry is export oriented. The same exercise can be applied to Spain:

Figure 12. Data crossing from the first two industry characteristics for Spain



Source: own elaboration

In Spain, the most populated industries in terms of number of companies do not have large shares of its sales bound to external markets. Most industries are present in the bottom left quadrant, which means that the number of companies operating in each of these classifications is below the average and oriented to the internal market. Even though the vertical axis is different (and so has to be due to the divergence in dimension between both countries), there appears to be more dispersion of the points for Portugal than for Spain.

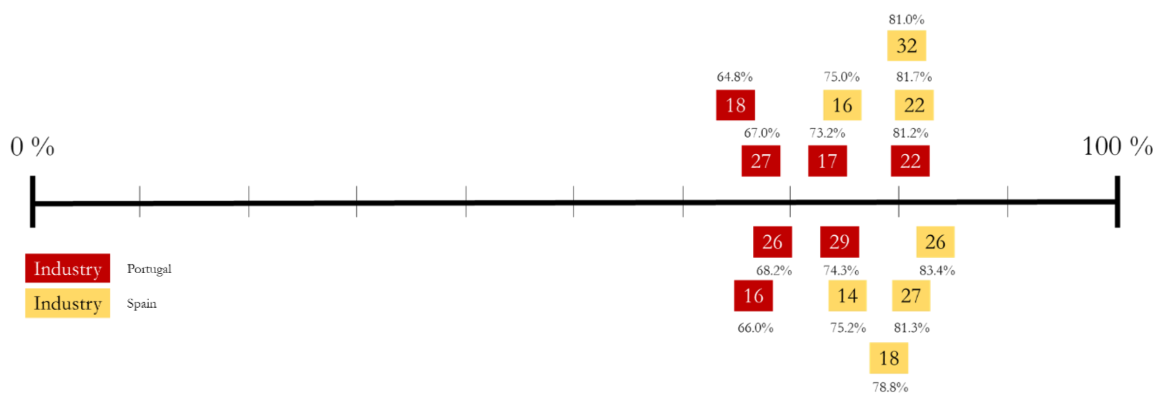
6.3 Industry electricity expenditures on total energy costs ratio

Alongside with identifying the most export-oriented industries, it is necessary to classify or rank them according to the share of electricity costs on the total energy costs:

$$Industry\ electricity\ expenditures\ on\ total\ energy\ costs\ ratio = \frac{Industry\ electricity\ expenditures}{Industry\ total\ energy\ costs} \times 100$$

The purpose behind the calculation of this ratio is to measure the weight that electricity costs have in the total energy costs of a given division. It stands clear that firms can have different sources of power – typically they are electricity, natural gas or petroleum products – which is why it is important to determine this ratio: the higher the value, the more impact a shift on electricity prices or consumption might have on the competitiveness of the firm. Similarly to the export intensity ratio, the top-7 industries for both countries are below. The remaining values are in table 23 and 24 in annex.

Figure 13. Industry electricity expenditures on total energy costs ratio calculations



Source: own elaboration

Electricity expenditures seem to represent the vast majority of energy costs, with some activities going beyond the 80% line. In fact, more than 81% of the total energy costs of companies operating under the activity code no. 22 – manufacture of rubber and plastic products – are due to electricity costs, indicating that this power source might be essential to the industry. Another example is activity code no. 26 – manufacture of computer, electronic and optical products – on which 83.4% and 68.2% of energy costs are due to electricity expenditures, respectively for Spain and Portugal.

Even though the top positions in the figure above are more densely populated by yellow squares, the overall ratio considering all industries' electricity expenditures and energy costs is higher for Portugal than it is for Spain. On average, in Portugal, for each 100€ of energy costs, 59.09€ are due to the electricity consumption, while in Spain this value is 58.80€.

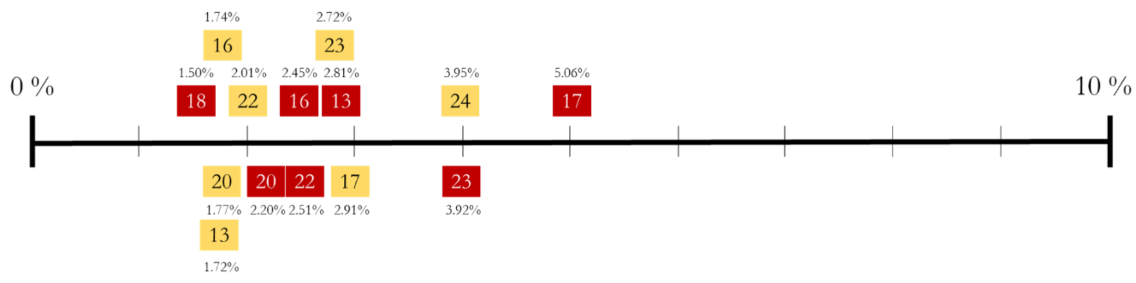
6.4 Industry electricity expenditures on production ratio

The next ratio to be considered is calculated as follows:

$$Industry\ electricity\ expenditures\ on\ production\ ratio = \frac{Industry\ electricity\ expenditures}{Industry\ production\ value} \times 100$$

The purpose behind the calculation of this ratio is to measure the weight that electricity expenditures have in the total value of production of a given industry, i.e. how much electricity (in €) is required to generate one unit of produced goods. This helps us understand the dependency that a given economic activity's output has towards electricity. The situation with the top-7 industries as of 2019 was as follows. The remaining values are in the tables 25 and 26 in annex.

Figure 14. Industry electricity expenditures on production ratio calculations



Source: own elaboration

Activity sector no. 17 – manufacture of paper and paper products – has an output highly dependent on electricity: for each 100€ of product produced, about 5.06€ have to be paid to the retailer of electricity in Portugal and about 2.91€ have to be paid to the retailer of electricity in Spain. Undoubtedly, this value has impact on the competitiveness of the firms associated with this output. There appears to be a cohesion in terms of the most electricity-impacted outputs between both countries, as the top positions are populated similarly, though Portugal seems to have a higher overall share of electricity costs on production value: on average, by 2019, for each 100€ produced in Portugal, 1.65€ were paid to the retailer of electricity, while this value was 1.23€ for the Spanish side.

6.5 Defining the target

The goal with the calculation of the previous ratios is twofold. On the one hand, the first two ratios provide relevant information on the propensity of a given industry to export its sales and the representativeness of the same industry on the national economy in terms of number of companies. On the other hand, the last two ratios paint an accurate picture of the share that electricity has on key business metrics. The table 19 in annex sums up the rankings that each activity code registered on the previous ratios for the year 2019. The column "Total PT" and "Total ES" are nothing more than the sum of the ranking positions (positions are ordered in ascent order, meaning that the higher the value in each cell, the more attractive the industry is) for each of the four ratios for each country. Assuming a point system based on the volume of this column, we can generate conclusions based on the four criteria of attractiveness. Portugal and Spain's top-7 is populated as follows:

Table 7. Simulation output for Portugal

Industry 22	Manufacture of rubber and plastic products
Industry 16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
Industry 13	Manufacture of textiles
Industry 15	Manufacture of leather and related products
Industry 23	Manufacture of other non-metallic mineral products
Industry 14	Manufacture of wearing apparel
Industry 29	Manufacture of motor vehicles, trailers and semi-trailers

Table 8. Simulation output for Spain

Industry 22	**Manufacture of rubber and plastic products**
Industry 16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
Industry 18	Printing and reproduction of recorded media
Industry 24	Manufacture of basic metals
Industry 27	Manufacture of electrical equipment
Industry 32	Other manufacturing
Industry 25	Manufacture of fabricated metal products, except machinery and equipment

7. Conclusions

While the topic of electricity liberalization is largely covered in the literature, the measures of its success are relatively scarce, not consensual and oftentimes contradictory. Thus, the main purpose of this dissertation was to study the MIBEL liberalized retail market of electricity for industrial consumers over the past 10 years, regarding market structure and price dynamics.

After some conceptualization needed to understand the value chain of electricity, as well as how the European legislation guided Portugal and Spain to the constitution of MIBEL, we present and discuss previous literature regarding retail markets and market liberalization. Then, the MIBEL wholesale market is briefly explained, as it has is very important to potentiate all the value chain activities downstream. Right after these background concepts, the performance of the liberalized retail market of each country is studied, as well as its performance specifically for the industrial segment. We demonstrate that the liberalized retail market penetration is a progressive process that is already clearly dominating the Portuguese and Spanish markets, as a very large portion of the consumption of electricity is currently being supplied by a competitive retailer, although there are still movements to be made regarding the number of customers associated with the liberalized market. Particularly for the industrial segment, we conclude that the penetration of the liberalized market in both countries is almost complete, whether in terms of number of customers or in terms of the supplied electricity, and that the concentration levels are dropping. Before the empirical analysis, we drill down on the price formation process, regarding its components, which could be regulated and unregulated, with the purpose of explaining that the structure of the retail prices of electricity in the liberalized market of Portugal and Spain is very similar. Thus, in order to explain retail price differences, an econometric model was formulated, based on previous approaches in the literature, with focus on the components of energy and network access tariffs of the pricing structure mentioned above. The goal of the model was to understand what variables have a significant effect on the evolution of the retail prices of electricity for the most representative industrial consumption band.

We demonstrate that the retail prices dynamics are not allowing customers to capture the advantages of the introduction of competition in the Iberian market, as retail prices are not harmonized between countries. The results of the empirical study suggest that market concentration has a negative coefficient, which is against the economical principal of perfect competition, but is in line with previous studies. Furthermore, the results of the simulation for Portugal show that the higher the share of solar, wind and hydro generation on the total generation of the country, the lower the retail price of electricity. For Spain, hydro technology failed to be statistically significant, though wind and solar have a negative impact on the retail price, similarly to Portugal. Nuclear showed to be insignificant at the 5% level. As for the wholesale strategies of buyers, the higher the coverage of demand with the spot market, the lower the retail price is in Spain. In Portugal, it works the other way around. There was, however, equilibrium for both countries regarding the coverage of demand with the derivatives market: the higher the traded volumes, the higher the retail price of electricity for industrial consumers. Moreover, specifically for Spain, the volatility of the spot market increases the retail price. Finally, the network access tariffs proved to be impactful in both countries, with a positive coefficient. The results of the model show that the retail price is undoubtedly impacted by the production mix, the wholesale strategy of buyers and the market concentration.

Lastly, it is presented a list of industries with an export-oriented business model and an electricity-intensive production process, that could see their exterior competitiveness harmed due to this inability to capture the benefits of competition in electricity retail markets and due to the retail price disequilibrium between countries.

Finally, the present dissertation has some limitations to consider. Due to data unavailability, the electricity industrial retail prices considered apply to different consumption bands. Although we proved in the introduction section that the retail price dynamics for both countries shows divergences in prices, we could not obtain monthly data, which compromised the credibility of an eventual regression.

As a future research possibility, if data is found, the retail price dynamics could be studied specifically for the industries in the identified simulation output according to the NACE Rev. 2 codes.

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Annexes

Table 9. Past 10 year evolution of the variable Sol

Varia-ble	Year	Portugal				Spain			
		Average	Maximum	Minimum	Standard deviation	Average	Maximum	Minimum	Standard deviation
Sol	2010	0.43%	0.67%	0.15%	0.0019	2.28%	3.20%	1.00%	0.0080
	2011	0.56%	0.83%	0.20%	0.0020	2.73%	3.70%	1.30%	0.0084
	2012	0.85%	1.23%	0.47%	0.0026	2.93%	4.00%	1.60%	0.0082
	2013	0.97%	1.53%	0.41%	0.0038	3.08%	4.40%	1.80%	0.0091
	2014	1.30%	2.30%	0.40%	0.0060	3.10%	4.40%	1.50%	0.0104
	2015	1.61%	2.28%	0.84%	0.0053	3.10%	4.40%	1.80%	0.0082
	2016	1.44%	2.08%	0.60%	0.0049	3.07%	4.50%	1.60%	0.0098
	2017	1.58%	2.01%	0.94%	0.0043	3.28%	4.40%	1.80%	0.0094
	2018	1.53%	2.19%	0.94%	0.0046	3.03%	4.40%	1.70%	0.0095
	2019	2.28%	3.43%	0.96%	0.0081	3.61%	4.60%	2.10%	0.0090
	Total	**1.25%**	**3.43%**	**0.15%**	**0.0071**	**3.02%**	**4.60%**	**1.00%**	**0.0096**

Source: REN, REE

Table 10. Past 10 year evolution of the variable Wnd

Variable	Year	Portugal				Spain			
		Average	Maximum	Minimum	Standard deviation	Average	Maximum	Minimum	Standard deviation
Wnd	2010	17.75%	22.42%	10.47%	0.0346	15.73%	20.10%	10.50%	0.0338
	2011	18.59%	24.19%	11.10%	0.0381	15.88%	20.20%	10.70%	0.0273
	2012	23.54%	34.62%	16.88%	0.0459	17.96%	24.90%	13.20%	0.0370
	2013	24.13%	31.09%	14.63%	0.0434	20.84%	29.50%	12.30%	0.0480
	2014	23.62%	29.77%	15.00%	0.0448	19.89%	28.50%	10.20%	0.0533
	2015	23.21%	32.39%	13.50%	0.0513	18.80%	26.80%	12.70%	0.0408
	2016	21.52%	28.60%	15.24%	0.0398	18.99%	29.40%	11.50%	0.0528
	2017	21.89%	29.90%	16.81%	0.0406	19.11%	24.90%	14.80%	0.0371
	2018	22.11%	33.61%	9.84%	0.0723	19.58%	33.10%	12.10%	0.0578
	2019	27.25%	40.10%	17.01%	0.0550	21.44%	34.00%	12.90%	0.0562
	Total	22.36%	40.10%	9.84%	0.0543	18.82%	34.00%	10.20%	0.0489

Source: REN, REE

Table 11. Past 10 year evolution of the variable Hyd

Variable	Year	Portugal				Spain			
		Average	Maximum	Minimum	Standard deviation	Average	Maximum	Minimum	Standard deviation
Hyd	2010	30.34%	50.27%	11.32%	0.1423	15.26%	24.30%	7.00%	0.0563
	2011	22.47%	46.52%	10.00%	0.1113	11.40%	20.80%	5.60%	0.0468
	2012	12.38%	23.36%	6.68%	0.0565	7.72%	11.80%	4.80%	0.0231
	2013	27.10%	49.80%	14.30%	0.1013	14.45%	25.90%	8.80%	0.0499
	2014	29.67%	50.68%	13.67%	0.1311	15.41%	26.70%	8.00%	0.0637
	2015	17.31%	27.53%	9.03%	0.0624	11.17%	17.40%	7.00%	0.0342
	2016	26.74%	49.91%	12.37%	0.1445	14.57%	26.10%	7.20%	0.0655
	2017	10.00%	21.73%	5.01%	0.0527	7.53%	13.50%	3.80%	0.0289
	2018	21.50%	48.18%	9.85%	0.1142	13.90%	24.00%	7.00%	0.0503
	2019	16.81%	41.76%	6.03%	0.0892	10.00%	21.80%	5.60%	0.0425
	Total	**21.43%**	**50.68%**	**5.01%**	**0.1256**	**12.14%**	**26.70%**	**3.80%**	**0.0559**

Source: REN, REE

Table 12. Past 10 year evolution of the variable Nuc

Variable	Year	Spain			
		Average	Maximum	Minimum	Standard deviation
Nuc	2010	21.73%	24.50%	18.10%	0.0189
	2011	20.85%	24.10%	17.50%	0.0196
	2012	21.83%	24.90%	16.00%	0.0286
	2013	20.88%	23.40%	17.40%	0.0186
	2014	21.64%	25.30%	16.80%	0.0248
	2015	21.53%	24.30%	17.60%	0.0227
	2016	22.58%	25.10%	18.20%	0.0252
	2017	22.50%	26.90%	16.70%	0.0299
	2018	21.53%	25.40%	18.10%	0.0248
	2019	22.67%	26.70%	15.90%	0.0282
	Total	**21.77%**	**26.90%**	**15.90%**	**0.0243**

Source: REE

Table 13. Past 10 year evolution of the variable CR5

Variable	Year	Portugal	Spain
CR5	2010	1.00	0.88
	2011	1.00	0.83
	2012	1.00	0.78
	2013	0.99	0.78
	2014	0.94	0.77
	2015	0.93	0.82
	2016	0.90	0.82
	2017	0.86	0.78
	2018	0.80	0.73
	2019	0.80	0.72
	Average	**0.92**	**0.79**

Source: ERSE, CNMC

Table 14. Past 10 year evolution of the variable Std_OMIE

Variable	Year	Portugal			Spain		
		Average	Maximum	Minimum	Average	Maximum	Minimum
Std_OMIE	2010	5.71	10.01	1.93	6.08	10.64	1.90
	2011	4.34	8.83	2.08	4.77	9.14	2.81
	2012	6.67	13.99	3.75	7.30	14.24	3.77
	2013	11.10	27.71	3.81	11.49	27.87	3.83
	2014	8.90	14.57	4.06	9.21	15.16	4.06
	2015	7.47	12.44	4.20	7.59	12.43	4.32
	2016	6.17	10.79	2.27	6.25	10.71	2.30
	2017	5.69	11.74	2.32	6.15	12.98	2.32
	2018	5.40	12.63	2.37	5.76	12.83	2.35
	2019	5.71	13.29	2.77	5.92	13.26	2.80
	Total	**6.72**	**27.71**	**1.93**	**7.05**	**27.87**	**1.90**

Source: OMIP

Table 15. Past 10 year evolution of the variable Std_OMIP

Variable	Year	Portugal			Spain		
		Average	Maximum	Minimum	Average	Maximum	Minimum
Std_OMIP	2010	0.79	2.08	0.13	1.11	2.85	0.13
	2011	0.63	1.63	0.15	0.62	1.65	0.15
	2012	0.53	1.02	0.22	0.53	1.02	0.22
	2013	0.49	1.33	0.16	0.47	1.03	0.18
	2014	0.60	1.34	0.22	0.63	1.39	0.22
	2015	0.40	0.84	0.07	0.34	0.69	0.07
	2016	0.35	0.70	0.13	0.32	0.70	0.08
	2017	0.60	1.21	0.23	0.60	1.21	0.23
	2018	0.47	0.75	0.10	0.46	0.75	0.10
	2019	0.83	1.95	0.28	0.83	1.95	0.28
	Total	**0.56**	**2.08**	**0.07**	**0.59**	**2.85**	**0.07**

Source: OMIP

Table 16. Past 10 year evolution of the variable Nat

Variable	Year	Portugal	Spain
		Average value	Average value
Nat	2010	31.3	17.1
	2011	33.0	17.8
	2012	38.3	19.1
	2013	41.1	12.9
	2014	55.9	14.3
	2015	52.7	13.8
	2016	54.5	14.3
	2017	46.2	12.5
	2018	40.2	12.0
	2019	36.8	9.3
	Total	**43.0**	**14.3**

Source: Eurostat

Table 17. Past 10 year evolution of the variable Ner

Variable	Year	Portugal			Spain		
		Average	Maximum	Minimum	Average	Maximum	Minimum
Ner	2010	64.55%	75.11%	53.27%	74.34%	81.37%	68.57%
	2011	66.92%	71.92%	61.65%	71.47%	77.22%	66.71%
	2012	100.90%	108.51%	96.98%	70.75%	76.21%	67.65%
	2013	98.25%	117.71%	74.22%	75.85%	89.50%	68.82%
	2014	102.78%	119.49%	99.71%	71.10%	84.07%	63.53%
	2015	101.46%	105.49%	98.73%	70.99%	75.78%	65.02%
	2016	100.46%	103.26%	98.12%	73.66%	79.89%	68.60%
	2017	102.08%	106.45%	98.92%	76.06%	79.24%	69.82%
	2018	101.22%	103.51%	98.15%	72.02%	75.36%	69.14%
	2019	101.36%	102.62%	100.14%	70.35%	72.99%	67.30%
	Total	**94.00%**	**119.49%**	**53.27%**	**72.66%**	**89.50%**	**63.53%**

Source: OMIE, CMVM, REE and REN

Table 18. Past 10 year evolution of the variable Ibe

Variable	Year	Portugal	Spain
		Average value	Average value
Ibe	2010	8.26%	8.26%
	2011	11.16%	11.16%
	2012	12.80%	12.80%
	2013	16.08%	16.08%
	2014	18.10%	18.10%
	2015	10.06%	10.06%
	2016	11.52%	11.52%
	2017	6.59%	6.59%
	2018	5.72%	5.72%
	2019	4.84%	4.84%
	Total	**10.51%**	**10.51%**

Source: OMIP annual reports

Table 19. NACE Rev. 2 activity codes

10	**Manufacture of food products**
11	Manufacture of beverages
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31	Manufacture of furniture
32	Other manufacturing
33	Repair and installation of machinery and equipment

Table 20. Export intensity breakdown for Portugal (2019)

NACE REV.2 ACTIVITY SECTOR		PORTUGAL		
		Export value (€)	Industry total sales (€)	Industry export intensity
10	Manufacture of food products	2 582 424 493	13 994 121 605	18,45%
11	Manufacture of beverages	883 626 704	3 565 713 797	24,78%
13	Manufacture of textiles	1 859 494 553	3 697 928 515	50,28%
14	Manufacture of wearing apparel	2 611 815 580	3 984 630 657	65,55%
15	Manufacture of leather and related products	1 589 867 140	2 605 194 115	61,03%
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1 576 972 761	3 529 924 932	44,67%
17	Manufacture of paper and paper products	1 208 986 946	4 473 366 126	27,03%
18	Printing and reproduction of recorded media	90 303 468	1 034 966 282	8,73%
20	Manufacture of chemicals and chemical products	2 430 064 430	5 055 482 156	48,07%
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	648 500 833	1 451 724 163	44,67%
22	Manufacture of rubber and plastic products	2 788 917 106	4 724 290 325	59,03%
23	Manufacture of other non-metallic mineral products	1 615 185 359	4 646 046 335	34,76%
24	Manufacture of basic metals	1 499 114 892	2 960 128 535	50,64%
25	Manufacture of fabricated metal products, except machinery and equipment	2 663 776 828	7 573 028 480	35,17%
26	Manufacture of computer, electronic and optical products	999 431 399	2 746 697 722	36,39%
27	Manufacture of electrical equipment	1 348 376 500	2 761 076 385	48,84%
28	Manufacture of machinery and equipment n.e.c	1 324 758 683	2 805 938 601	47,21%
29	Manufacture of motor vehicles, trailers and semi-trailers	8 993 877 817	11 277 042 394	79,75%
30	Manufacture of other transport equipment	635 899 735	991 121 078	64,16%
31	Manufacture of furniture	885 222 342	2 001 427 004	44,23%
32	Other manufacturing	418 472 931	1 028 122 194	40,70%
33	Repair and installation of machinery and equipment	125 726 486	2 056 176 939	6,11%

Table 21. Export intensity breakdown for Spain (2019)

NACE REV.2 ACTIVITY SECTOR		SPAIN		
		Export value (€)	Industry total sales (€)	Industry export intensity
10	Manufacture of food products	21 106 852 240	111 215 130 000	18,98%
11	Manufacture of beverages	3 229 259 510	19 580 710 000	16,49%
13	Manufacture of textiles	2 279 645 860	6 062 860 000	37,60%
14	Manufacture of wearing apparel	1 347 613 560	4 533 085 000	29,73%
15	Manufacture of leather and related products	1 765 165 240	4 307 234 000	40,98%

16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1 473 409 360	7 823 539 000	18,83%
17	Manufacture of paper and paper products	3 484 656 710	14 074 560 000	24,76%
18	Printing and reproduction of recorded media	644 039 460	6 189 843 000	10,40%
20	Manufacture of chemicals and chemical products	15 387 825 810	42 809 457 000	35,94%
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	5 886 600 460	15 629 205 000	37,66%
22	Manufacture of rubber and plastic products	7 077 592 380	21 805 829 000	32,46%
23	Manufacture of other non-metallic mineral products	6 043 871 840	21 637 644 000	27,93%
24	Manufacture of basic metals	13 277 522 100	30 981 477 000	42,86%
25	Manufacture of fabricated metal products, except machinery and equipment	9 778 897 230	38 833 565 000	25,18%
26	Manufacture of computer, electronic and optical products	1 767 996 530	5 216 199 000	33,89%
27	Manufacture of electrical equipment	7 992 979 040	18 708 678 000	42,72%
28	Manufacture of machinery and equipment n.e.c	9 970 229 590	22 563 185 000	44,19%
29	Manufacture of motor vehicles, trailers and semi-trailers	40 453 836 930	75 572 798 000	53,53%
30	Manufacture of other transport equipment	9 043 485 700	17 364 371 000	52,08%
31	Manufacture of furniture	1 138 383 080	6 336 033 000	17,97%
32	Other manufacturing	1 483 507 880	4 727 955 000	31,38%
33	Repair and installation of machinery and equipment	462 576 530	10 343 806 000	4,47%

Table 22. Number of companies (2019)

	NACE REV.2 ACTIVITY SECTOR	**Portugal**	**Spain**
10	Manufacture of food products	9566	24713
11	Manufacture of beverages	2023	5206
13	Manufacture of textiles	3578	6456
14	Manufacture of wearing apparel	8747	9009
15	Manufacture of leather and related products	3087	4310
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	5070	9573
17	Manufacture of paper and paper products	560	1557
18	Printing and reproduction of recorded media	2412	13815
20	Manufacture of chemicals and chemical products	836	3475
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	167	337
22	Manufacture of rubber and plastic products	1094	4051
23	Manufacture of other non-metallic mineral products	3819	7487
24	Manufacture of basic metals	315	1245
25	Manufacture of fabricated metal products, except machinery and equipment	11927	32481
26	Manufacture of computer, electronic and optical products	316	2181

27	Manufacture of electrical equipment	574	1835
28	Manufacture of machinery and equipment n.e.c	1527	5534
29	Manufacture of motor vehicles, trailers and semi-trailers	689	1591
30	Manufacture of other transport equipment	245	807
31	Manufacture of furniture	4479	11051
32	Other manufacturing	3395	10082
33	Repair and installation of machinery and equipment	4381	14423

Table 23. Electricity expenditures on total energy costs ratio for Portugal (2019)

NACE REV.2 ACTIVITY SECTOR		**PORTUGAL**		
		Electricity expenditures (€)	Total energy costs (€)	Electricity expenditures on total energy costs ratio
10	Manufacture of food products	184 917 643,94 €	377 168 997 €	49,03%
11	Manufacture of beverages	32 913 513,80 €	64 337 803 €	51,16%
13	Manufacture of textiles	100 768 195,84 €	169 617 429 €	59,41%
14	Manufacture of wearing apparel	28 394 247,30 €	54 289 395 €	52,30%
15	Manufacture of leather and related products	23 281 170,28 €	36 066 527 €	64,55%
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	82 025 733,23 €	124 365 207 €	65,96%
17	Manufacture of paper and paper products	225 529 742,01 €	308 141 672 €	73,19%
18	Printing and reproduction of recorded media	15 231 747,14 €	23 499 921 €	64,82%
20	Manufacture of chemicals and chemical products	106 652 313,98 €	203 535 584 €	52,40%
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	16 006 385,00 €	27 577 784 €	58,04%
22	Manufacture of rubber and plastic products	114 661 626,24 €	141 216 360 €	81,20%
23	Manufacture of other non-metallic mineral products	169 547 630,48 €	281 087 823 €	60,32%
24	Manufacture of basic metals	31 801 819,86 €	83 600 598 €	38,04%
25	Manufacture of fabricated metal products, except machinery and equipment	86 353 239,65 €	171 319 760 €	50,40%
26	Manufacture of computer, electronic and optical products	11 052 484,05 €	16 209 005 €	68,19%
27	Manufacture of electrical equipment	23 504 785,60 €	35 098 500 €	66,97%
28	Manufacture of machinery and equipment n.e.c	24 718 627,46 €	46 133 266 €	53,58%
29	Manufacture of motor vehicles, trailers and semi-trailers	65 019 961,96 €	87 454 917 €	74,35%
30	Manufacture of other transport equipment	7 105 290,33 €	11 366 161 €	62,51%
31	Manufacture of furniture	27 564 287,53 €	46 856 245 €	58,83%
32	Other manufacturing	7 685 637,47 €	15 147 595 €	50,74%
33	Repair and installation of machinery and equipment	9 692 364,77 €	35 685 611 €	27,16%

Table 24. Electricity expenditures on total energy costs ratio for Spain (2019)

NACE REV.2 ACTIVITY SECTOR		SPAIN		
		Electricity expenditures (€)	Total energy costs (€)	Electricity expenditures on total energy costs ratio
10	Manufacture of food products	1 073 429 000,00 €	1 828 614 000 €	58,70%
11	Manufacture of beverages	133 368 000,00 €	249 320 000 €	53,49%
13	Manufacture of textiles	101 661 000,00 €	160 623 000 €	63,29%
14	Manufacture of wearing apparel	13 978 000,00 €	18 594 000 €	75,17%
15	Manufacture of leather and related products	21 160 000,00 €	31 296 000 €	67,61%
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	133 321 000,00 €	177 762 000 €	75,00%
17	Manufacture of paper and paper products	399 019 000,00 €	681 805 000 €	58,52%
18	Printing and reproduction of recorded media	66 381 000,00 €	84 221 000 €	78,82%
20	Manufacture of chemicals and chemical products	720 192 000,00 €	1 581 572 000 €	45,54%
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	115 367 000,00 €	169 302 000 €	68,14%
22	Manufacture of rubber and plastic products	424 717 000,00 €	519 741 000 €	81,72%
23	Manufacture of other non-metallic mineral products	566 444 000,00 €	1 416 290 000 €	39,99%
24	Manufacture of basic metals	1 113 460 000,00 €	1 672 215 000 €	66,59%
25	Manufacture of fabricated metal products, except machinery and equipment	307 052 000,00 €	472 333 000 €	65,01%
26	Manufacture of computer, electronic and optical products	24 258 000,00 €	29 101 000 €	83,36%
27	Manufacture of electrical equipment	120 849 000,00 €	148 699 000 €	81,27%
28	Manufacture of machinery and equipment n.e.c	90 919 000,00 €	135 998 000 €	66,85%
29	Manufacture of motor vehicles, trailers and semi-trailers	372 113 000,00 €	501 278 000 €	74,23%
30	Manufacture of other transport equipment	69 192 000,00 €	100 504 000 €	68,85%
31	Manufacture of furniture	38 619 000,00 €	60 048 000 €	64,31%
32	Other manufacturing	22 495 000,00 €	27 761 000 €	81,03%
33	Repair and installation of machinery and equipment	23 719 000,00 €	55 426 000 €	42,79%

Table 25. Electricity expenditures on production ratio for Portugal (2019)

NACE REV.2 ACTIVITY SECTOR		PORTUGAL		
		Electricity expenditures (€)	Production value (€)	Electricity expenditures on production ratio
10	Manufacture of food products	184 917 643,94 €	12 347 833 919 €	1,50%
11	Manufacture of beverages	32 913 513,80 €	3 383 742 807 €	0,97%
13	Manufacture of textiles	100 768 195,84 €	3 590 009 559 €	2,81%
14	Manufacture of wearing apparel	28 394 247,30 €	3 876 838 362 €	0,73%
15	Manufacture of leather and related products	23 281 170,28 €	2 532 337 173 €	0,92%

16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	82 025 733,23 €	3 354 058 944 €	2,45%
17	Manufacture of paper and paper products	225 529 742,01 €	4 461 462 227 €	5,06%
18	Printing and reproduction of recorded media	15 231 747,14 €	1 012 461 829 €	1,50%
20	Manufacture of chemicals and chemical products	106 652 313,98 €	4 847 330 070 €	2,20%
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	16 006 385,00 €	1 331 295 415 €	1,20%
22	Manufacture of rubber and plastic products	114 661 626,24 €	4 560 792 825 €	2,51%
23	Manufacture of other non-metallic mineral products	169 547 630,48 €	4 324 333 906 €	3,92%
24	Manufacture of basic metals	31 801 819,86 €	2 793 004 847 €	1,14%
25	Manufacture of fabricated metal products, except machinery and equipment	86 353 239,65 €	7 274 129 114 €	1,19%
26	Manufacture of computer, electronic and optical products	11 052 484,05 €	2 545 428 362 €	0,43%
27	Manufacture of electrical equipment	23 504 785,60 €	2 557 518 225 €	0,92%
28	Manufacture of machinery and equipment n.e.c	24 718 627,46 €	2 691 776 796 €	0,92%
29	Manufacture of motor vehicles, trailers and semi-trailers	65 019 961,96 €	11 274 838 221 €	0,58%
30	Manufacture of other transport equipment	7 105 290,33 €	1 000 533 509 €	0,71%
31	Manufacture of furniture	27 564 287,53 €	1 928 391 404 €	1,43%
32	Other manufacturing	7 685 637,47 €	951 301 405 €	0,81%
33	Repair and installation of machinery and equipment	9 692 364,77 €	1 876 152 977 €	0,52%

Table 26. Electricity expenditures on production ratio for Spain (2019)

NACE REV.2 ACTIVITY SECTOR		**SPAIN**		
		Electricity expenditures (€)	Production value (€)	Electricity expenditures on production ratio
10	Manufacture of food products	1 073 429 000,00 €	105 533 480 000 €	1,02%
11	Manufacture of beverages	133 368 000,00 €	18 891 481 000 €	0,71%
13	Manufacture of textiles	101 661 000,00 €	5 905 536 000 €	1,72%
14	Manufacture of wearing apparel	13 978 000,00 €	4 423 027 000 €	0,32%
15	Manufacture of leather and related products	21 160 000,00 €	4 352 249 000 €	0,49%
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	133 321 000,00 €	7 647 605 000 €	1,74%
17	Manufacture of paper and paper products	399 019 000,00 €	13 727 373 000 €	2,91%
18	Printing and reproduction of recorded media	66 381 000,00 €	6 133 485 000 €	1,08%
20	Manufacture of chemicals and chemical products	720 192 000,00 €	40 637 496 000 €	1,77%
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	115 367 000,00 €	15 034 393 000 €	0,77%
22	Manufacture of rubber and plastic products	424 717 000,00 €	21 084 524 000 €	2,01%

23	Manufacture of other non-metallic mineral products	566 444 000,00 €	20 815 346 000 €	2,72%
24	Manufacture of basic metals	1 113 460 000,00 €	28 212 325 000 €	3,95%
25	Manufacture of fabricated metal products, except machinery and equipment	307 052 000,00 €	38 360 443 000 €	0,80%
26	Manufacture of computer, electronic and optical products	24 258 000,00 €	5 148 074 000 €	0,47%
27	Manufacture of electrical equipment	120 849 000,00 €	17 692 748 000 €	0,68%
28	Manufacture of machinery and equipment n.e.c	90 919 000,00 €	22 027 583 000 €	0,41%
29	Manufacture of motor vehicles, trailers and semi-trailers	372 113 000,00 €	68 478 708 000 €	0,54%
30	Manufacture of other transport equipment	69 192 000,00 €	17 065 697 000 €	0,41%
31	Manufacture of furniture	38 619 000,00 €	6 170 896 000 €	0,63%
32	Other manufacturing	22 495 000,00 €	4 468 072 000 €	0,50%
33	Repair and installation of machinery and equipment	23 719 000,00 €	10 252 198 000 €	0,23%

Table 27. Industry characteristics simulation output

Industry	**Portugal**					**Spain**				
	A	B	C	D	Total PT	A	B	C	D	Total ES
10	3	21	15	3	42	6	21	14	6	47
11	4	11	10	6	31	3	11	11	4	29
13	16	15	20	12	63	15	13	16	7	51
14	21	20	5	7	53	10	15	2	17	44
15	19	13	9	15	56	17	10	6	12	45
16	12	19	18	17	66	5	16	17	16	54
17	5	5	22	20	52	7	4	21	5	37
18	2	12	16	16	46	2	19	15	18	54
20	14	8	17	8	47	14	8	18	3	43
21	11	1	13	10	35	16	1	12	13	42
22	18	9	19	22	68	12	9	19	21	61
23	6	16	21	13	56	9	14	20	1	44
24	17	3	11	2	33	19	3	22	10	54
25	7	22	12	4	45	8	22	13	9	52
26	8	4	1	19	32	13	7	5	22	47
27	15	6	8	18	47	18	6	10	20	54
28	13	10	7	9	39	20	12	4	11	47
29	22	7	3	21	53	22	5	8	15	50
30	20	2	4	14	40	21	2	3	14	40
31	10	18	14	11	53	4	18	9	8	39
32	9	14	6	5	34	11	17	7	19	54
33	1	17	2	1	21	1	20	1	2	24