sustainability

MDPI

Article

Sustainable Business Model Based on Open Innovation: Case Study of Iberdrola

Izaskun Alvarez-Meaza [1,*], Naiara Pikatza-Gorrotxategi [1] and Rosa Maria Rio-Belver [2]

[1] Technology, Foresight and Management (TFM) Group, Department of Industrial Organization and Management Engineering, Faculty of Engineering, University of the Basque Country, Pl. Ingeniero Torres Quevedo, 48013 Bilbao, Spain; naiara.picaza@ehu.eus

[2] Technology, Foresight and Management (TFM) Group, Department of Industrial Organization and Management Engineering, Faculty of Engineering, University of the Basque Country, C/Nieves Cano 12, 01006 Vitoria, Spain; rosamaria.rio@ehu.eus

* Correspondence: izaskun.alvarez@ehu.eus; Tel.: +34-946-014-245

Received: 29 October 2020; Accepted: 16 December 2020; Published: 19 December 2020

Abstract: The change in business management towards a vision based on open innovation has opened the doors to knowledge transfer between organizations, promoting scientific–technological collaborations resulting in new research that opens the way to new technological innovations. Therefore, the objective of this study is to see how the company Iberdrola has oriented its management strategy towards an open innovation approach, analyzing both its scientific and technological development through a bibliometric and network analysis. The results highlight that Iberdrola has always considered scientific and technological development to be part of its strategic approach as a means of disseminating and transferring knowledge. Furthermore, it can be concluded that the implementation of strategic axes related to sustainable development in an open innovation environment has improved the results of its scientific and technical production, and also the company's financial results.

Keywords: Iberdrola; open innovation; sustainability; bibliometric analysis; network analysis

1. Introduction

In recent decades, the business innovation model has evolved from a closed to an open approach to the environment [1]. In the closed model, innovations were generated by means of investments in R&D (push system), circumscribed by the limits of the company itself; in contrast, in an open model, innovations are generated through interactions with external agents of the R&D system, increasing their social value [2]. In the former innovation model, the knowledge and technology required for production, distribution, and marketing were developed and remained within the company [3]; there was very little interaction with external entities so they were able to keep not only new ideas under control but also all their knowledge [2].

In an increasingly globalized market, resources are constantly flowing, moving, changing, and increasing in complexity. As employees start moving from one company to another, so does information and technology, making it very difficult for the firm to contain ideas [4,5]. However, this transition to an open innovation model is not entirely natural; companies are also an active agent in this process [6]. The exploration of resource complementarity and economies of scale attempts at easier entry into markets, the minimization of costs and risks, tacit collusion, and obtaining know-how all promote collaboration between different economic agents [7]. As a result, companies have gradually reversed their ways of investing in their research toward a collaborative method.

In this dynamic context, open innovation (OI) has appeared in recent decades. As Chesbrough describes [1], OI represents an innovation paradigm shift from a closed to an open model. OI can be understood as the intentional utilization of incoming and outgoing knowledge to further a firm's innovation and to extend markets to innovate externally. The definition perceives organizations as being able to use information and procedures from inside and outside the firm, and this is the way it has to be if they wish to progress technologically [8]. When a company is part of a collaborative structure and shares innovation and knowledge, it will be more effective in achieving its goals. Therefore, companies working in an OI environment are more likely to improve their results [9,10]. Within this open environment, partnerships aimed at achieving sustainable innovation processes are becoming increasingly important compared to other innovations [11].

Sustainable innovation within OI has become an essential part of many companies' business models [12]. To achieve competitive environmental advantages in today's business environment, it is essential to share knowledge [13]. This is because the complexity that sustainability issues can have makes companies more dependent on the knowledge and innovations of other companies [14]. This is why many companies use external sources of knowledge, enter into partnerships, and strengthen their R&D. Thus, through their sustainable innovations, they increase their business benefits [15].

In fact, it is the companies that innovate more in sustainability that collaborate more with other companies to develop these innovations and are usually the ones that produce the most environmental impacts [12]. Sustainability is a way to ensure that members of society, including companies, do not harm biodiversity, implementing appropriate policies on sustainable innovations [15,16]. Companies have to take into account growing consumer concern about reducing environmental impact and their environmental footprint and that the policies that penalize this environmental impact are increasingly restrictive [17]. Therefore, if the company integrates sustainability into its business management strategy, a sustainable business model will be achieved, as well as balanced social development [18].

In a world facing new global challenges, such as the depletion of natural resources and global warming, the environment and people's values are becoming increasingly diverse and complex [19]. In this context, in September 2015, the United Nations adopted the 2030 Agenda for Sustainable Development Goals (SDG) as its core [20]. In 2016 an initiative called "Society 5.0" was proposed by the Japanese Cabinet in its 5th Science and Technology Basic Plan [21]. This is a new super-smart society that aims to make people live healthier and more comfortably [22]. Society 5.0 focuses on achieving SDGs such as "conscientious consumption and production", "sustainable cities and towns", "industrialization, innovations and infrastructure", and "cheap and low-cost energy", among others [23].

An example of a company that integrates OI and sustainability in its organizational model is Iberdrola [24], a Spanish energy company with over 170 years of history. It is the world's energy leader as well as the largest producer of wind energy [25]. Iberdrola is the only Spanish electricity company among the 100 most sustainable companies in the world and incorporated the SDGs approved by the UN in September 2015 into its business strategy [26]. In addition, the innovative execution of Iberdrola's sustainable business model responds to the demand for continuous improvement in environmental, social, and governance (ESG) metrics, combined with 20 years of outstanding financial performance [27]. The long-term value creation of a sustainable economic model can be measured through ESG issues, which better help to determine future company financial performance and reputation [28,29]. Therefore, for Iberdrola its reputation is strongly linked to sustainability, clearly manifested in the main sustainability indexes [30]. In order to carry out research into innovative and sustainable projects, Iberdrola has established OI as the mainstay of its activities, which means collaborating with universities, technology centers, and other companies by implementing an open R&D model [27].

Bibliometric techniques establish a method that allows the analysis of a large amount of academic literature, facilitating the identification and quantification of research results in a given field of interest or organization [30]. Therefore, bibliometric analysis becomes a tool that enables the geographic location of research, the main drivers, collaborative networks, and research hubs, among others [31].

Likewise, bibliometrics is an analytics tool used to process information obtained in patent databases. In addition, another analytics tool is network analysis that makes it possible to identify and quantify collaboration patterns between organizations, authors, and countries, including ascertaining the main topics of research [32,33]. The use of these techniques allows large amounts of data to be analyzed and, therefore, their results allow new research projects, new collaborations, or even funding of technological research areas to be channeled along an optimal path [34].

A review of the literature identified several works related to OI, but none that analyzes the impact of implementing strategic lines of innovation management based on an OI vision of scientific and technological development. As far as OI is concerned, Medeiros et al. [35] carried out a bibliometric analysis of OI in the agrifood chain. Lopes and Carvalho [36] analyzed how OI can affect organization and innovation performance using a systematic literature review based on bibliometric analysis. De Paulo et al. [37] provided a bibliometric analysis of OI in developed and emerging countries between the years 2000 and 2014. Furthermore, in another study carried out by de Paulo et al. [38], the conclusions lead to a direct relationship between the improvement of business competitiveness and the implementation of OI practices. The research conducted by Della Corte et al. [39] carried out bibliometric analysis of sustainable tourism in the field of OI to analyze the state of the art of sustainable tourism in the digital era. Finally, Chaurasia et al. [40], through a review of literature, considered the main aspects of OI for sustainability, thus establishing their interrelationships.

Therefore, the aim of this work is to determine how the company Iberdrola bases its strategy of development and dissemination of science and technology in an environment based on OI, channeling sustainability in that background. In addition, the financial impact of the company is evaluated by analyzing the ESG issue related to innovation management, specifically based on OI. For this, the use of bibliometric techniques and network analysis allows us to generate and identify the main collaborations, both in science and technology, and in turn, identify the traceability of "sustainability" in this scientific and technological environment. All this will give the scientific and technological community an opportunity to see the paths that the company is taking and thus increase collaborations, adding value to the organizational environment based on OI as a business strategy.

2. Materials and Methods

To achieve the objective, the methodology followed employs three important phases before analyzing the results (see Figure 1). These three phases facilitate the identification of scientific collaborations of Iberdrola, both in a general area of development and based on a specification of terms relating to management and sustainability, and the identification of collaborations in the development of patents based on a particular technological field determined by the Cooperative Patent Classification (CPC): Y (general tagging of new technological developments). This method can be applied to any other organization whose strategic approach is based on an OI model. This could give rise to future research whose results will be used for feedback and improvement of strategic know-how.

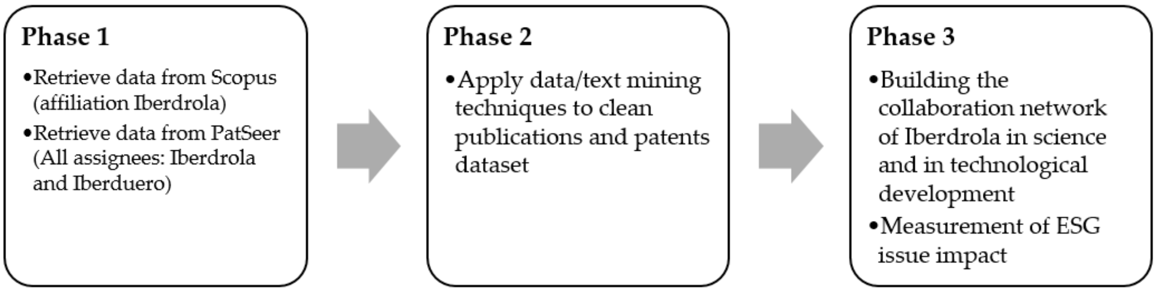

Figure 1. Methodological process phase by phase.

In order to build Iberdrola's collaboration network, the first step was focused on obtaining the data from Iberdrola's scientific publications and the data from the patents whose assignee and owner was

Iberdrola. To choose the scientific reference database, a search for "Iberdrola" in the field of affiliation or address in the two scientific publication databases Web of Science (WoS) and Scopus was performed, obtaining better results in Scopus (474 versus 278 in WoS). The Iberdrola scientific publications dataset is thus created from the documents identified in Scopus [41]. The search in Google Scholar is also interesting, since several studies have shown that the results are improved if the three databases are used [42]. However, in this case it distorts the analysis, given that up to 26,000 publications are obtained in which "Iberdrola" as a term appears, because Google Scholar lacks certain functionalities to do the required bibliometric search [43,44]. Regarding the patents dataset, this was generated using PatSeer [45], a comprehensive global full-text patent database. The search was performed in all possible assignee fields (Normalized Assignee, Assignee Original, Current Assignee, Assignee Non Latin, and All Assignees in US Reassignment History) based on "Iberdrola" and "Iberduero" (the name of the company before it was named Iberdrola). A total of 126 patent families were obtained whose priority year, or year they were invented, was between 1930 and 2019.

In the second phase, the use of text and data mining techniques allowed the two datasets to be cleaned. For this purpose, the two datasets obtained in the first phase were imported to VantagePoint (VP) software [46], through which the raw data could be classified and the data cleaned thanks to the use of fuzzy matching techniques, grouping the terms that had the same meaning.

Once the cleaning was done, phase three of the research began, generating the collaboration networks that would allow us to identify the main nodes of scientific–technological collaboration of Iberdrola and its fields of action. To do this, we used both VP, which allowed us to create the co-occurrence matrices of the fields to study, and Gephi software [47], which allowed us to generate and visualize the collaboration networks based on these matrices. The network analysis allowed us to identify the main research partners and analyze the behavior of certain research fields (such as sustainability, OI, or other strategic management models). Subsequently, the network analysis identified Iberdrola's main allies in the development of technology in a particular field (such as that defined by Cooperative Patent Classification (CPC) Y02, relating to the development of new technologies that mitigate climate change). In addition, the evolution of Iberdrola was analyzed both in the development of new scientific and technological research fields through the analysis of keywords and patent classification codes, using VP and Power BI.

Once the scientific and technological profile of Iberdrola was determined, the impact of the innovation process was analyzed through the quantification of the cause and effect of an ESG issue.

3. Results

The purpose of this study was to identify and analyze the scientific–technological development carried out by the company Iberdrola, which in turn became a very important output indicator to measure the company's OI practices.

3.1. Iberdrola's Scientific Collaboration Network

After further investigating and updating the study by Naiara et al. [48], the company Iberdrola began to develop its scientific activity during its diffusion phase in 1992, collaborating on three articles. In addition, the company has collaborated on an average of 19 publications per year in the last 15 years, with 2009 being the most productive year with 33 publications, as shown in Figure 2 (on a logarithmic basis). However, the most remarkable thing was the significant growth in the number of citations received for these articles, which means that they were of great interest to new developments within the scientific and technological community.

In total, Iberdrola published articles with authors from 29 different countries. In this case, we were interested in ascertaining Iberdrola's level of collaboration, both nationally and internationally, in order to identify with which institutions and countries it is most likely to carry out its scientific research and to identify the geographical location of the scientific production. In addition, the main countries of scientific collaboration were the UK, USA, France, and Germany.

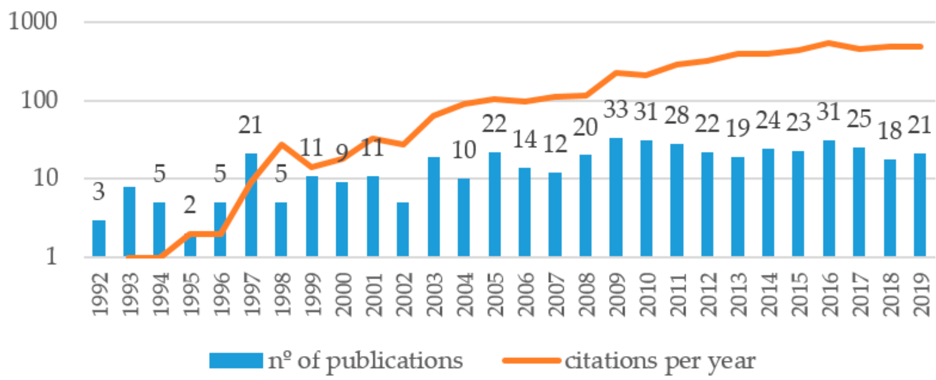

Figure 2. Number of publications and citations per year.

In terms of production by country, as shown in Table 1, the country with the most publications was Spain (430), followed by the UK (36), the USA (29), and France with 27 documents. In general, Europe countries were the main driving force behind Iberdrola's scientific development. Nonetheless, if the map of collaborations between countries is generated and the degree of the relationship quantified using the software Gephi (see Figure 3), it is observed that it was mainly the European countries with the highest levels of collaboration. Some authors believe that this may be due to funding of projects by the European Commission, which promotes collaboration between European countries. With the exception of the USA, whose level of collaboration was lower than the productive one, it was still ranked among the best positions, and Qatar, whose level of collaboration was lower than the top 10.

Table 1. Ranking of most productive and collaborative countries.

Ranked	Countries	Number of Publications	Most Collaborative Countries	Weighted Degree
1	Spain	430.0	Spain	189.0
2	United Kingdom	36.0	France	85.0
3	United States	29.0	United Kingdom	77.0
4	France	27.0	Italy	75.0
5	Germany	26.0	Germany	69.0
6	Italy	26.0	United States	45.0
7	Qatar	16.0	Switzerland	40.0
8	Switzerland	15.0	Sweden	34.0
9	Denmark	10.0	Denmark	26.0
10	Sweden	10.0	Austria	20.0

In general, there was greater activity in countries where Iberdrola had significant representation, such as Europe and America. Collaborations in the Asian market were less common in countries such as South Korea, Malaysia, Australia, Qatar, and Japan, which represent markets that are only beginning to develop.

As far as affiliations were concerned, in the clean-up phase the main sections of Iberdrola—Iberdrola, Iberdrola Distribution, Iberdrola Engineering and Construction, Iberdrola Engineering and Consulting, Iberdrola Renewables, Iberdrola Generation, Iberdrola Nuclear Generation, and Global Smart Grids Iberdrola—plus Iberdrola Internacional (depending on the country), were defined as independent affiliations. In order to identify Iberdrola's scientific collaboration activities, an effective method was a network analysis. The network was generated through a matrix of co-occurrences and plotted using Gephi (see Figure 4). As indicated in Figure 4, the isolated groups are small collaboration groups linked to Iberdrola Internacional, such as Iberdrola renewables US, which collaborates with NASA, the US Department of Energy, University of Washington, Santa Clara University, and the National Renewable Energy Laboratory, among others, and Iberdrola Portugal, which collaborates with companies in that country.

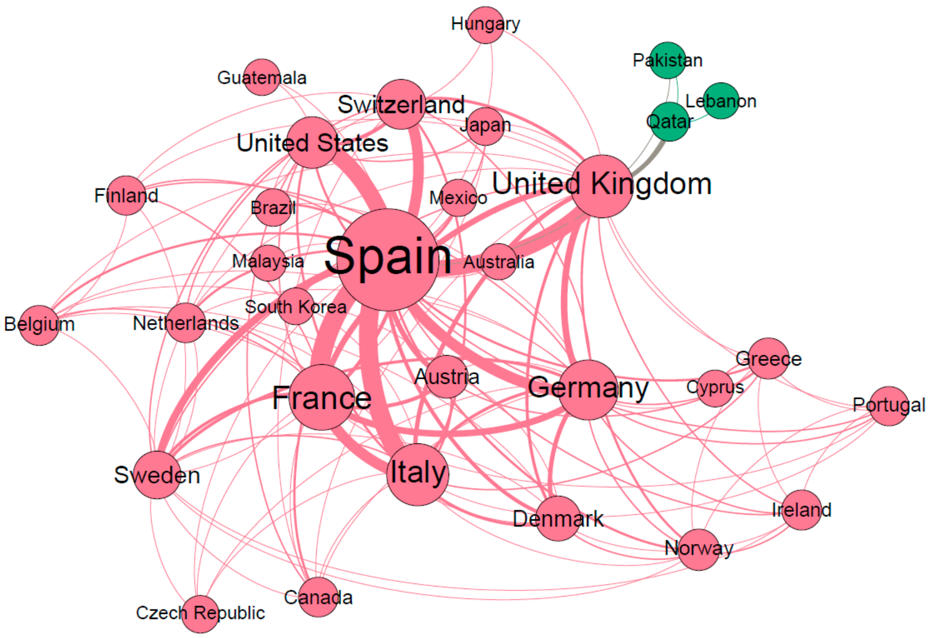

Figure 3. Iberdrola's scientific network: countries.

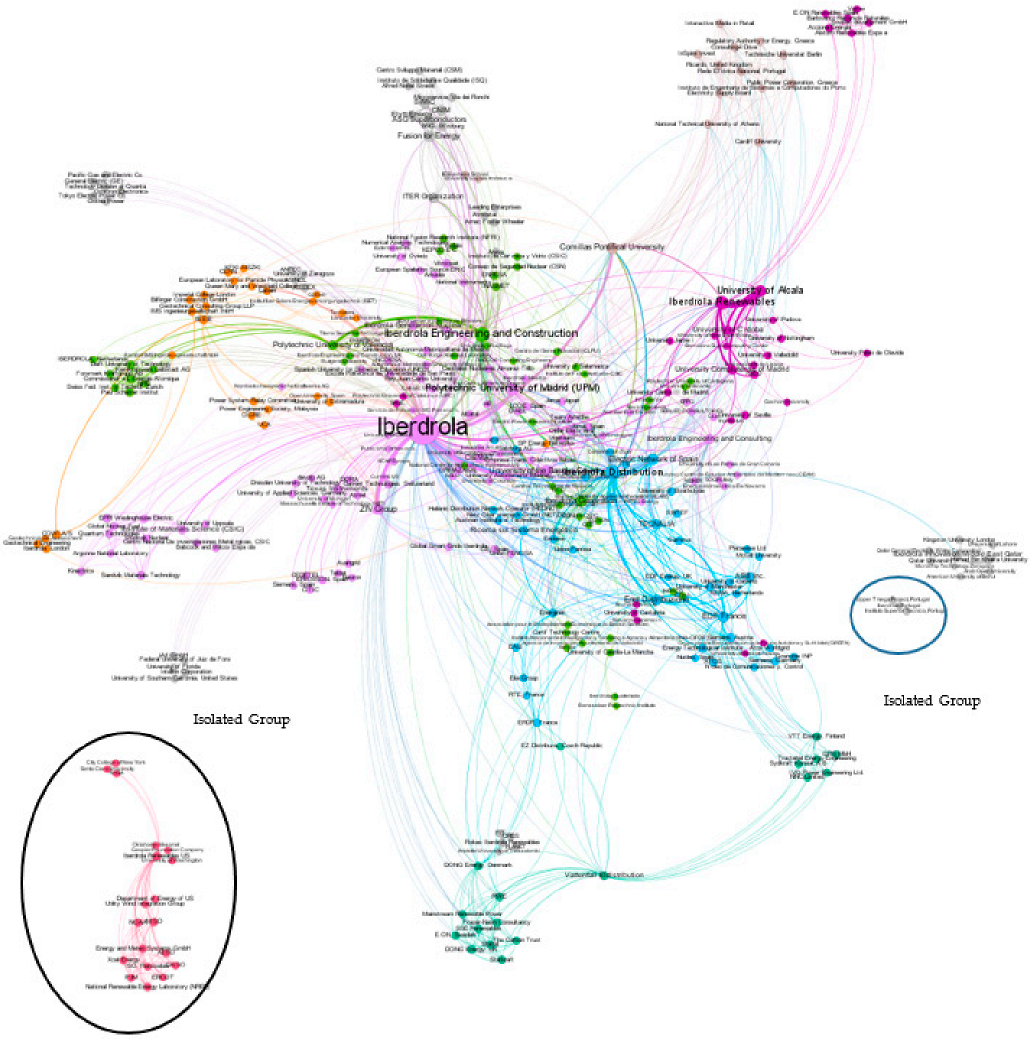

Figure 4. Iberdrola's scientific collaboration: organizations.

Iberdrola Spain was the central nucleus of the network, and collaborated with all national sections. It had a wide range of collaborations with universities (National: University of the Basque Country, Comillas Pontifical University, Polytechnic University of Madrid, Autonomous University of Madrid, University of Oviedo, and University of Burgos; International: University of Strathclyde, University of Michigan, University of Colorado, Lancaster University, University of Applied Science, and Dresden University), companies (ZIV, Texas Instruments, Team Arteche, Spanish Electrical Network (REE), Siemens, Jema Energy, Ormazabal, Current, General Electric, Gamesa, and DONG Energy—mainly companies from the electricity sector), and research centers (Massachusetts Institute of Technology (MIT), the European Organization for Nuclear Research (CERN), Tecnalia, Basque Center for Applied Mathematics (BCAM), and the European Laboratory for Particle Physics) (See Figure 5). Iberdrola Spain collaborated with all main sections except Iberdrola Nuclear Generation.

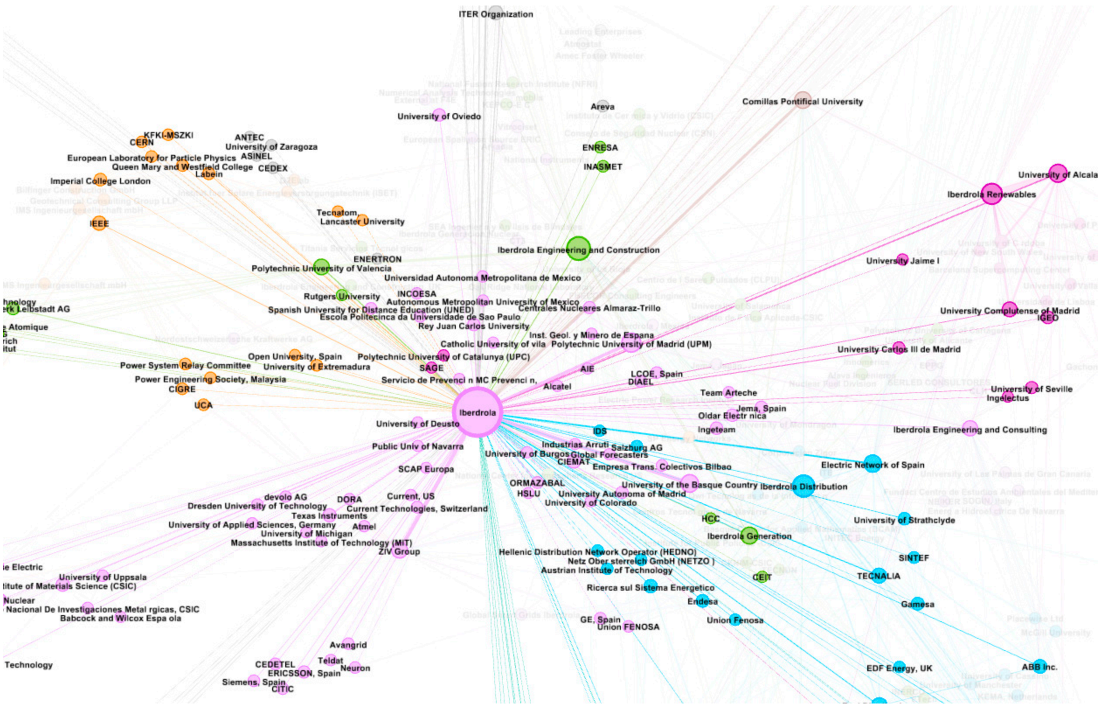

Figure 5. Iberdrola's scientific collaboration: Node Iberdrola.

In the case of Iberdrola Distribution, regarding universities, it collaborated mainly with Spanish universities such as Comillas Pontifical University, Polytechnic University of Madrid, University of the Basque Country, University of Salamanca, and University of Mondragon, and international ones such as University of Manchester and University of Cassino (see Figure 6). As far as other types of collaborations were concerned, the main companies with which it collaborated were the international companies EDF France, Enel Distribuzione, Siemens (Austria and Germany), and the national companies Team Arteche, Corporacion Zigor, Jema, and Ingeteam, among others. It also collaborated with research centers such as the Basque Center for Applied Mathematics (BCAM), the Energy Technological Institute, and the Austrian Institute of Technology.

As far as Iberdrola Engineering and Construction was concerned, it collaborated with various sections, namely, Iberdrola Nuclear Generation, Iberdrola Generation, Iberdrola Distribution, and Iberdrola Renewables. In addition, it collaborated mainly with research centers and companies, both Spanish and international, such as the National Fusion Research Institute (South Korea), mobiis (South Korea), Vitrociset (Italy), the Research Applications Laboratory (USA), Oak Ridge National Laboratory (USA), ASG Superconductors (Italy), International Thermonuclear Experimental Reactor ITER organization, Fusion for Energy (EU), Jema (Japan), and National Instruments (USA), among others. In this case, collaboration with universities (University of la Rioja, Polytechnic University of Madrid and Valencia, and University of Salamanca) did occur but with less intensity than in other sections of Iberdrola (see Figure 7).

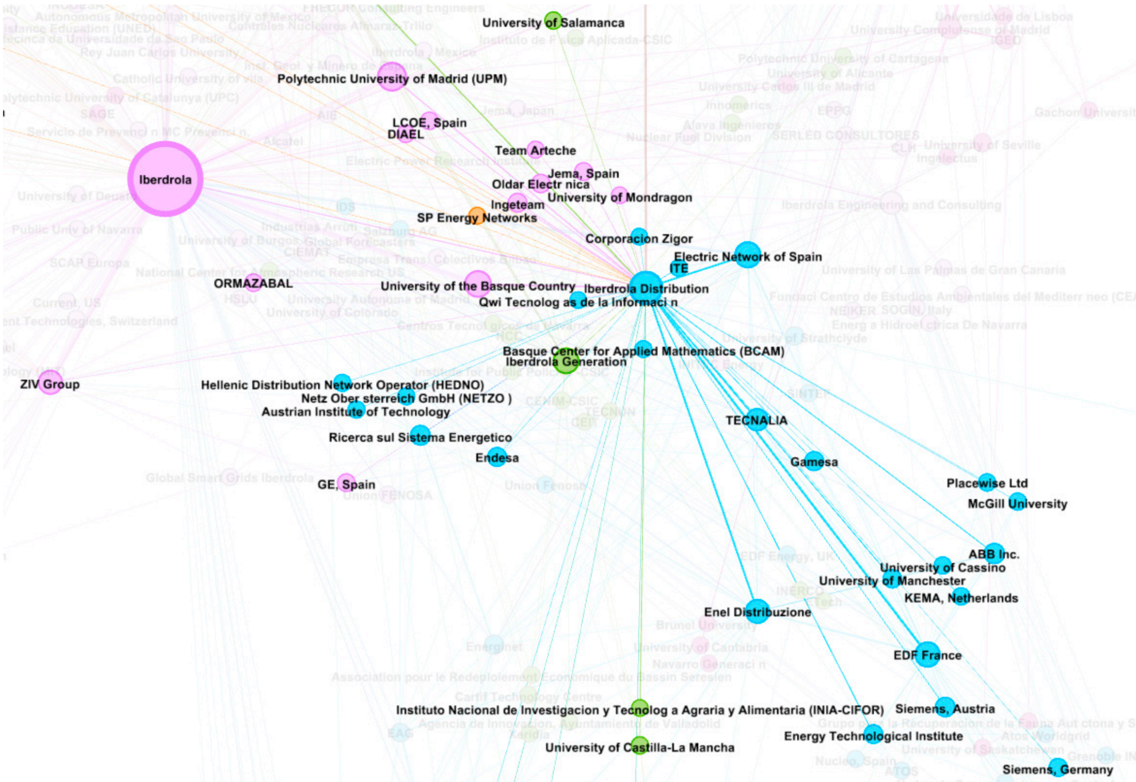

Figure 6. Iberdrola's scientific collaboration: Node Iberdrola Distribution.

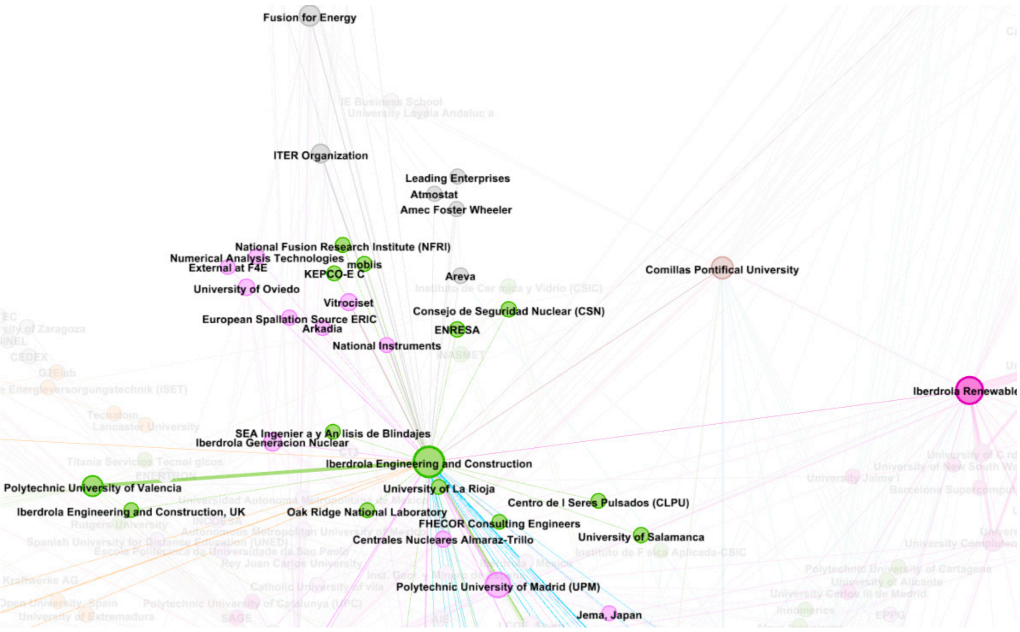

Figure 7. Iberdrola's scientific collaboration: Node Iberdrola Engineering and Construction.

Regarding Iberdrola Engineering and Consulting (see Figure 8), its main collaborators were Spanish universities (University Complutense of Madrid, University of the Basque Country, Polytechnic University of Madrid, and University of Las Palmas de Gran Canaria), research centers (NEIKER, CIEMAT, and the Foundation Center for Environmental Studies of the Mediterranean (CEAM)), consulting enterprises (EPPG/EBSCO and Serled Consultores) and international companies (CLH, VTT Energy Finland, and EDF France), as well as with nuclear organizations such as nuclear power plants and the Nuclear Safety Council (CSN).

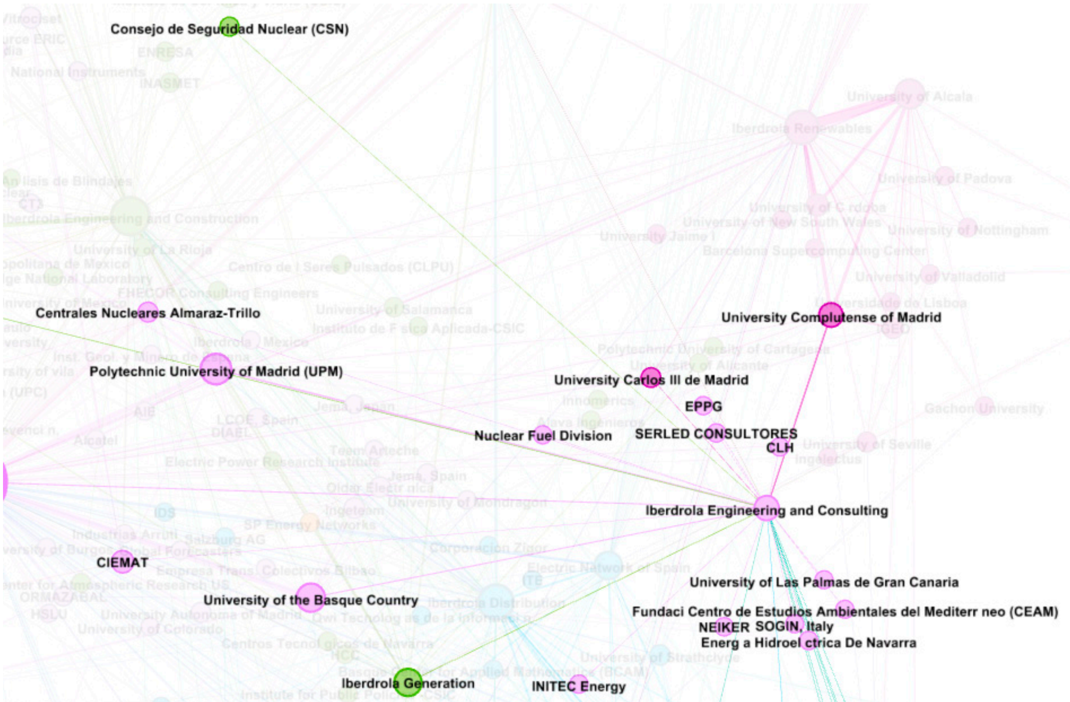

Figure 8. Iberdrola's scientific collaboration: Node Iberdrola Engineering and Consulting.

As far as Iberdrola Renewables was concerned (see Figure 9), its main collaborators were Spanish and international universities (University of Alcala, University Complutense of Madrid, University of Córdoba, University of Lisbon, University of Nottingham, and University of South Wales, among others). It also collaborated with companies and organizations such as Barcelona Supercomputing Center, Almston Renewables, Acciona Energia, and EON Spain, among others.

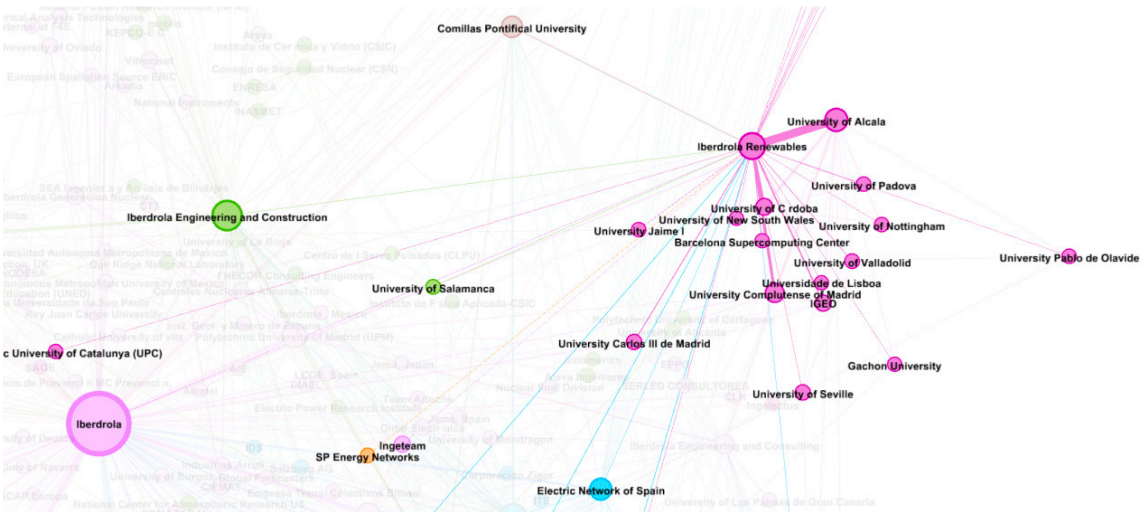

Figure 9. Iberdrola's scientific collaboration: Node Iberdrola Renewables.

Iberdrola Generation collaborated mainly with Spanish universities (Polytechnic University of Madrid, Autonomous University of Madrid, University of the Basque Country, Tecnun, Polytechnic University of Cartagena, University of Seville, Tecnun, and University of Salamanca, among others) and with Spanish research centers (Superior Council of Scientific Research (CSIC), Center for Technical Studies and Research (CEIT), the Electric Power Research Institute, and the Technological Centers of Navarra, among others). As regards Iberdrola Nuclear Generation, it collaborated with different sections of Iberdrola, some universities (Polytechnic University of Madrid and Valencia, University of Oviedo, Comillas Pontifical University, and Autonomous Metropolitan University of Mexico) and with Spanish engineering companies linked to the nuclear energy sector (SEA and CT3), as well as German companies related to the electricity sector (Nordostschweizerische Kraftwerke AG) (see Figure 10). It also collaborated with Fusion for Energy, the European Union organization handling Europe's contribution to the ITER project.

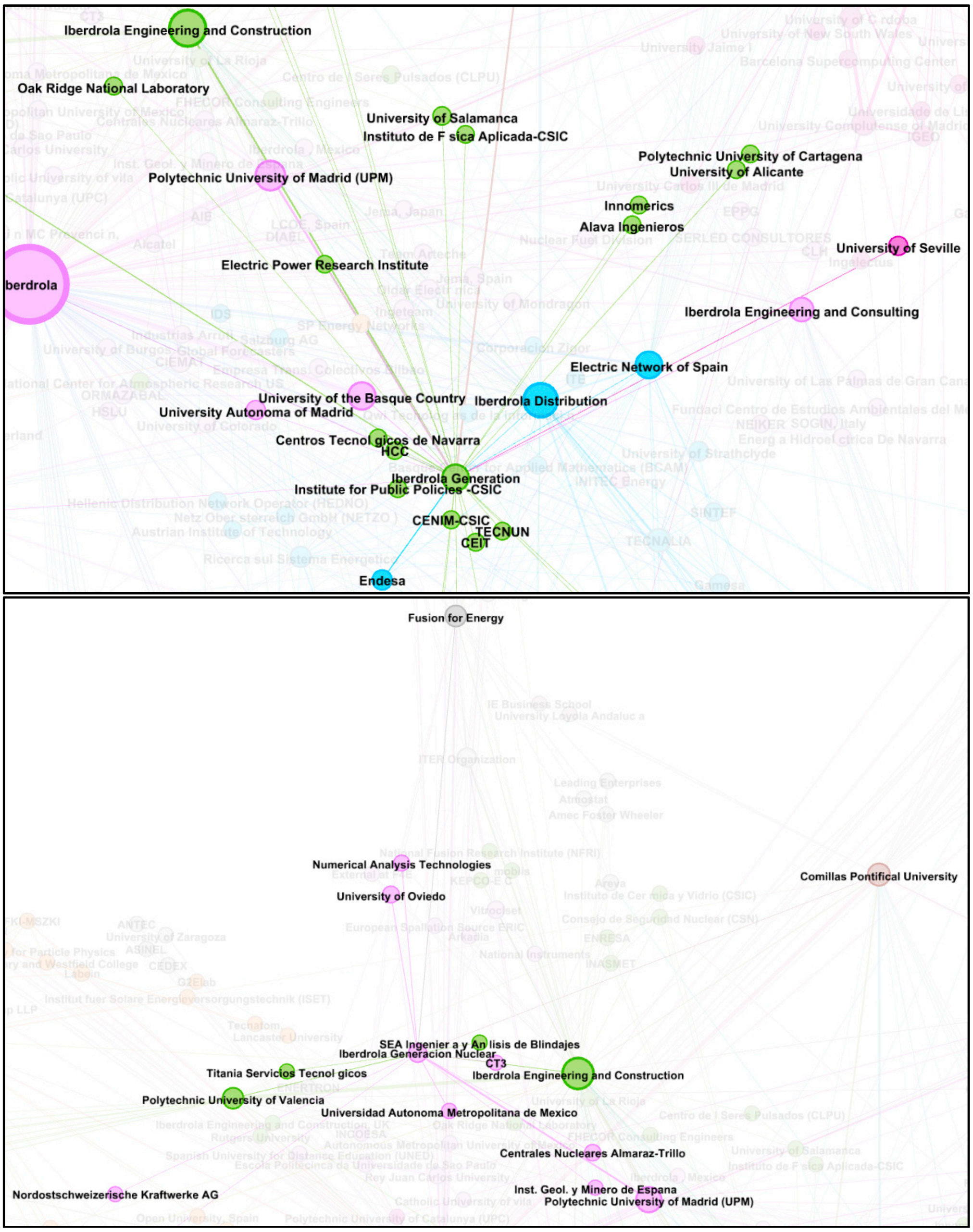

Figure 10. Iberdrola's scientific collaboration: Node Iberdrola Generation and Iberdrola Nuclear Generation.

Iberdrola's international sections, in general, played an important role when searching for allies in the corresponding country, creating geographically located working groups. With regard to Iberdrola's newest section, Global Smart Grids, Iberdrola collaborated with the University of the Basque Country, Tecnalia, CIEMAT, Neuron, and the ZIV group (see Figure 11).

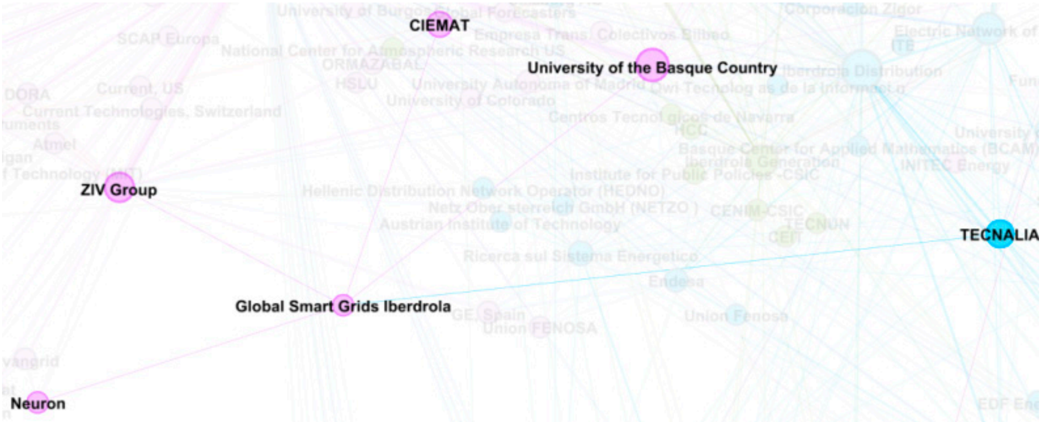

Figure 11. Iberdrola's scientific collaboration: Node Global Smart Grids Iberdrola.

In addition, the analysis of keywords or new terms generated over the years allowed us to identify the company's progress when researching new fields of scientific development. As indicated in Figure 12, the number of new terms grew as the number of publications increased, which indicated the company's interest in embracing a greater scientific dimension and expanding its scientific domains.

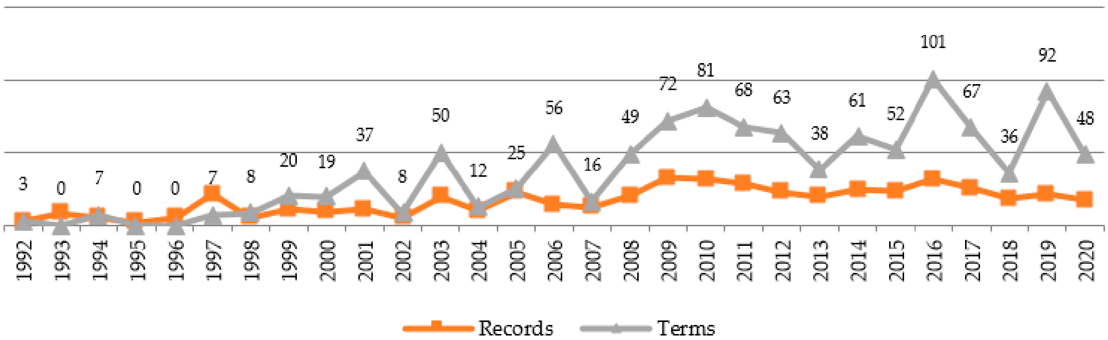

Figure 12. Evolution of scientific domains: new terms by year.

Iberdrola, apart from collaborating in the scientific development of its main area of business interest, namely energy, also collaborated in research areas related to business management, such as open innovation (the first year the term appeared was 2009), business (2000), technological innovation management (2002), knowledge management (2009), energy management (2009), risk management (2009), management of information (2010), strategy (2014), business schools (2020), sustainability (2020), and management (2020). Figure 13 shows the organizations involved in joint research with Iberdrola in these knowledge areas linked to business management.

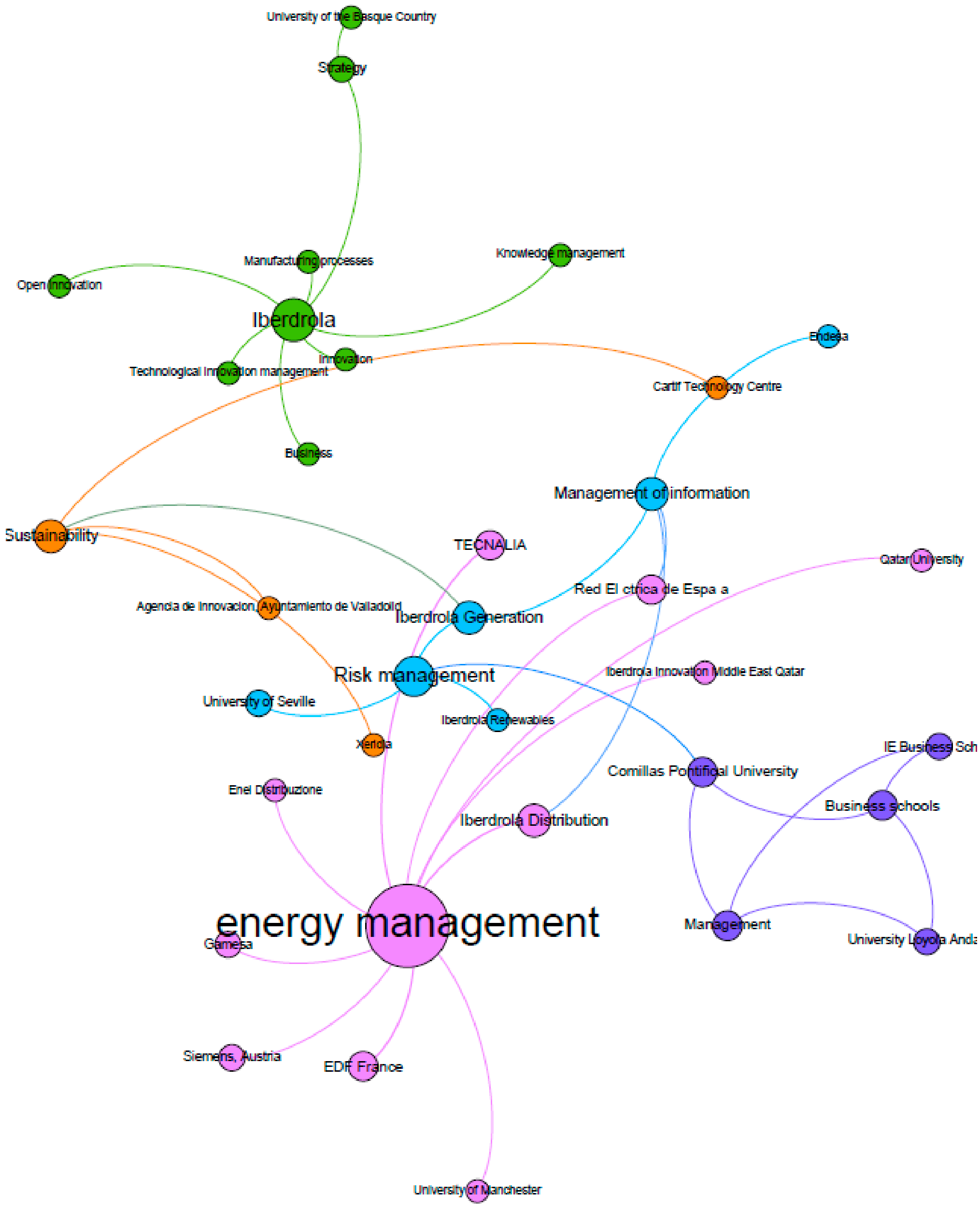

Figure 13. Scientific areas of business management and research organizations.

3.2. Iberdrola's Collaboration Network in Technological Developments

The analysis of the technological development carried out by Iberdrola was directed, on the one hand, to study the path that inventions have followed and the collaborative relations between the assignees of the patents, updating and extending the study carried out by Pikatza et al. [48] and, on the other hand, to identify collaborations in the technological field relative to the development of new sustainable technologies.

As indicated in Figure 14, the evolution of inventions evolved in such a way that there were periods that were more productive than others. For this reason, we analyzed the year in which the invention was created, also known as the priority year. The period between 1990 and 1996 stood out as the most productive. In addition, another interesting period, with variability in the number of inventions, was between 2008 and 2016.

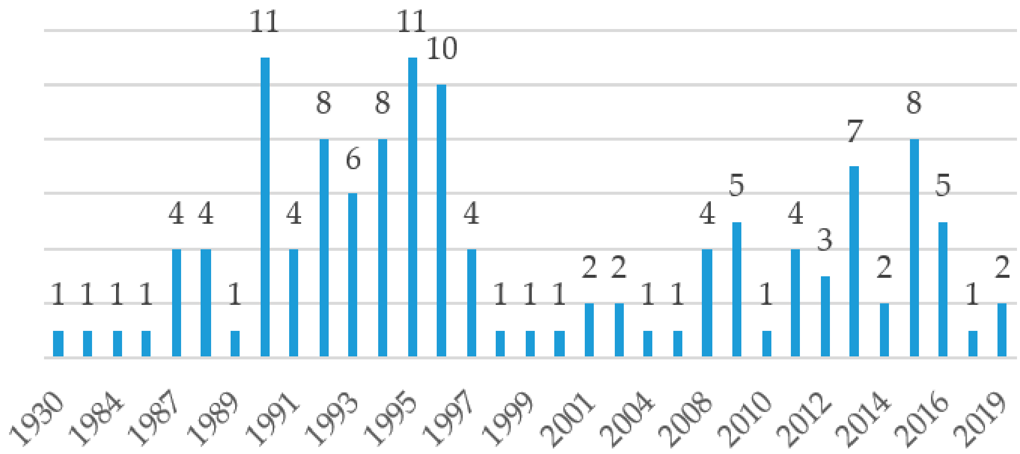

Figure 14. Evolution of patents by priority year.

With regard to the assignees, also called applicants or owners, according to the patent office, as indicated in Table 2, the beneficiaries with the largest number of patents, apart from Iberdrola and Iberduero and its affiliated companies Iberdrola Engineering and Construction and Iberdrola Generation, were companies from the electronic and communications sector (Angel Iglesias SA), energy suppliers (New York State Electric and Gas, Energetix, and Rochester Gas and Electric Corp), and renewable energies (Enertron and Avangrid).

Table 2. Ranking of most productive and collaborative assignees.

Ranked	Top Assignee	Number of Patent Families	Most Collaborative Assignee	Weighted Degree
1	Iberdrola	92.0	Iberdrola	108.0
2	Iberduero	20.0	Angel Iglesias SA	31.0
3	Angel Iglesias SA	19.0	Iberduero	30.0
4	New York State Electric Gas	13.0	Energetix Gmbh	17.0
5	Energetix Gmbh	12.0	New York State Electric and Gas	16.0
6	Iberdrola Engineering and Construction	12.0	Rochester Gas and Electric Corp	12.0
7	Iberdrola Generation	8.0	Es Inc	8.0
8	Rochester Gas and Electric Corp	7.0	University of The Basque Country	8.0
9	Enertron	5.0	Nasa	7.0
10	Avangrid	4.0	Electronica Arteche Hermanos	6.0

As for the collaborative relationships between the different assignees, the network generated allowed us to identify the collaborative groups with at least one patent. Two assignees that did not participate in their patents were identified with other assignees, namely Iberdrola Nuclear Generation and Iberdrola Engineering and Consulting. Figure 15 shows the different cooperation groups, with two isolated groups: Iberdrola Generation and Polytechnic University of Madrid, and the one headed by Iberdrola Renewables Spain and Iberdrola Engineering and Construction that collaborated mainly with universities. The main group, whose most important node was Iberdrola, had the largest number of collaborations. The degrees of the top relationships were quantified (see Table 2), and the level of collaboration that Iberdrola had with the University of the Basque Country, NASA, and with Electronica Arteche Hermanos stood out.

The technical domain of patent analysis allowed us to identify the main fields of technological development (see Figure 16). This classification of the patent based on the technical domain was specified by the technical expert of the patent office [49]. The main domains were apparatus, electrical machinery, energy, measurement, engines, pumps, turbines, and telecommunications, among the 26 different domains that the patents presented.

Figure 15. Collaboration network between assignees.

In addition, it is of interest to see the technical domains of the assignees; to do this, a network that relates the assignees with their technical domains was generated (see Figure 17). The network identified work groups based on technical domains.

For better comprehension, the three most important parts of the network were zoomed in on. As shown in Figure 18, the main technical domains of Iberdrola Nuclear Generation, Iberdrola Generation, Iberdrola Engineering and Construction, Iberdrola Renewables, Nac Uranio; Polytechnic University of Madrid (UPM), and University of La Coruña were related to engines, pumps, and turbines, among others, highlighting the link between Iberdrola Generation, UPM, University of

Salamanca, CLPU, and environmental technology. The biotechnology domain also appeared as an isolated area linked to Iberdrola Engineering and Construction.

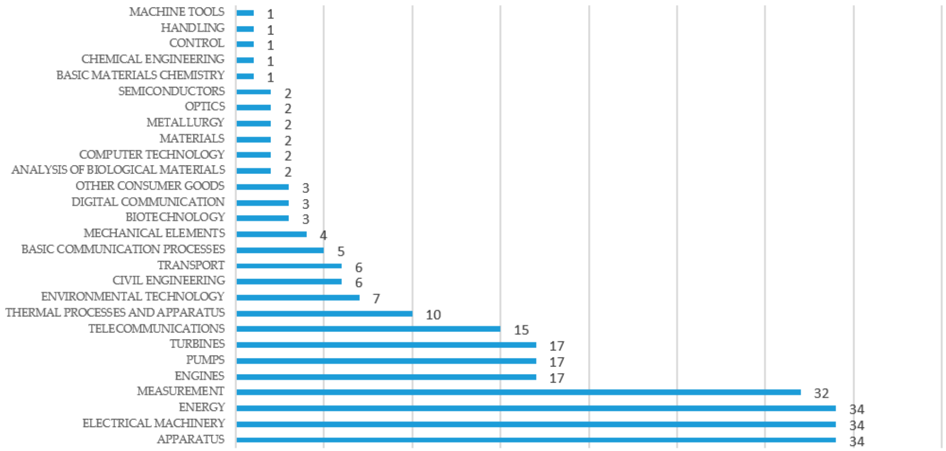

Figure 16. Technical domains of patents.

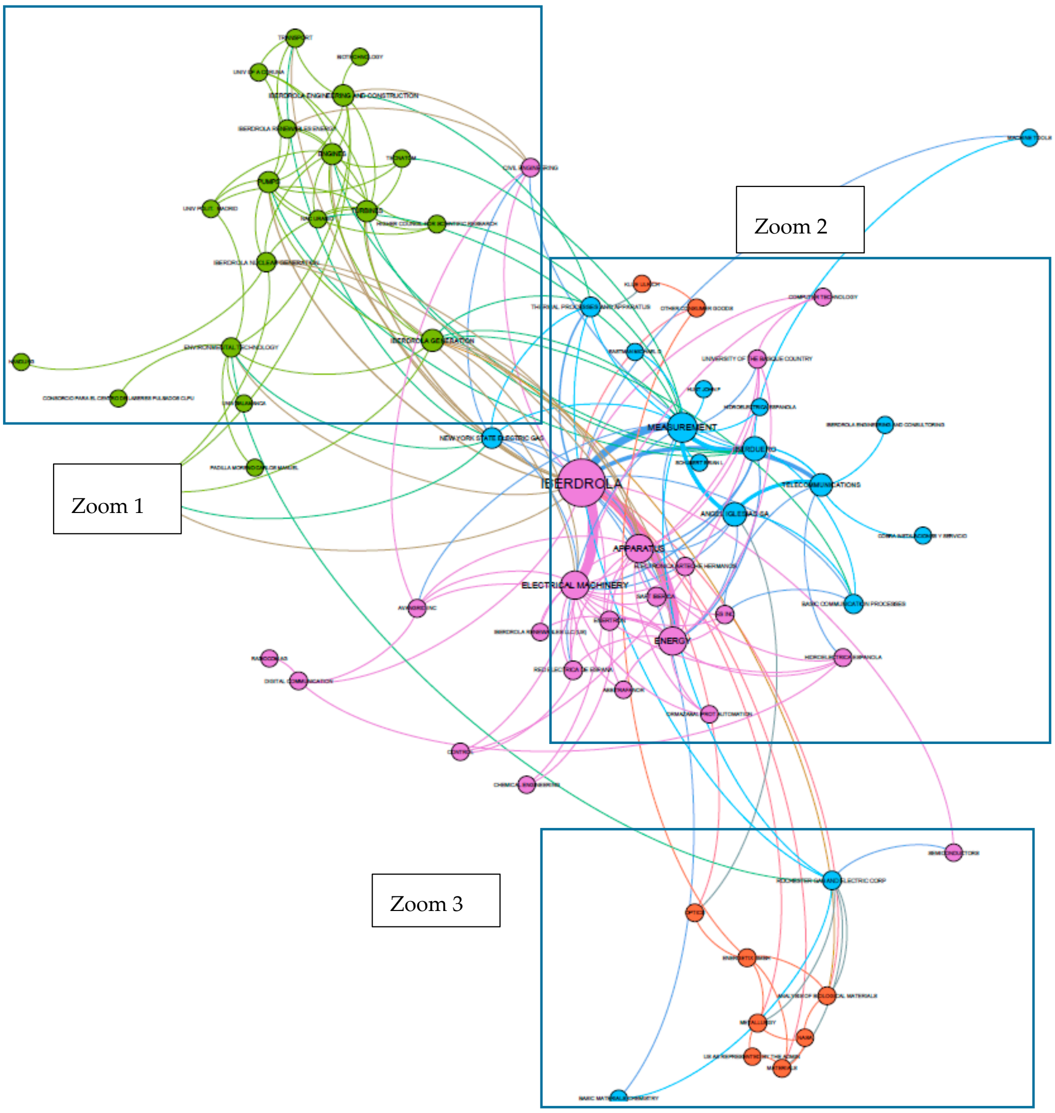

Figure 17. Network linking assignees and technical domains.

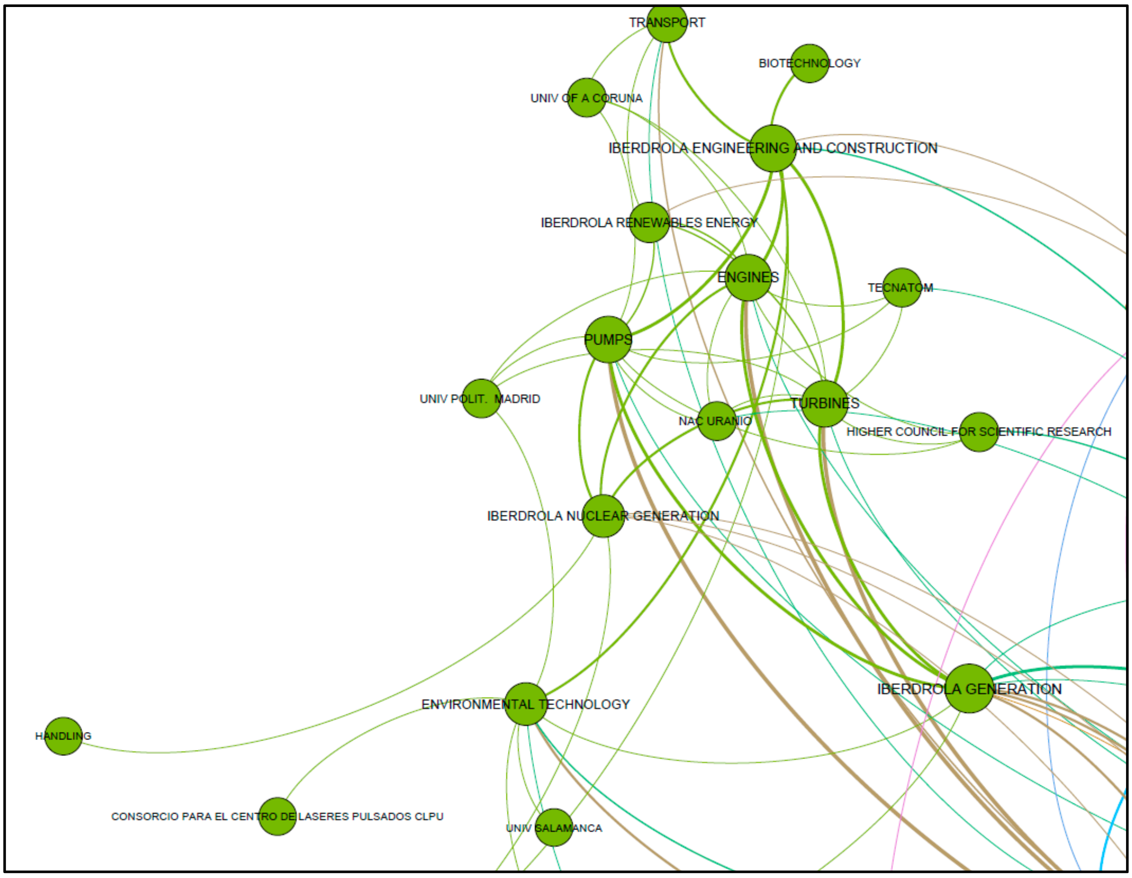

Figure 18. Zoom 1 of the network linking assignees and technical domains.

With regard to Iberdrola as the main company, in zoom 2 (Figure 19) we can see a greater diversification in domains. Nevertheless, they were mainly grouped in two clusters. In the first place were those linked to domains related to apparatus, energy, and electrical machinery, together with the companies Enertron, Electronica Arteche Hermanos, Red Electrica de España, Saft Iberica, Avangrid, and the University of the Basque Country, among others. In addition, Avangrid was also linked to digital communication and civil engineering, and the University of the Basque Country with computer technology. Second the blue cluster, with companies such as Angel Iglesias, Iberduero, New York State Electric and Gas, and Rochester Gas and Electric Corp focused on domains linked to measurement, telecommunications, thermal processes and apparatus, and basic communication processes.

Regarding another important cluster (orange), zoom 3, linked companies such as NASA, Energetix, and the US Administration with technical domains related to metallurgy, materials, optics, and analysis of biological materials (See Figure 20).

In order to deepen the technological development, patents were analyzed based on the Cooperative Patent Classification (CPC). More specifically, patents classified as Y02 (General Tagging of New Technological Developments: Technologies or Applications for Mitigation or Adaptation Against Climate Change) were analyzed in order to identify Iberdrola's collaborations with other assignees in the field of technological development for purposes based on sustainability. However, in order to clarify the meaning of the CPC codes offered by the patents, a network had to be made to link the technical domains with the CPC classifications (see Figure 21). The most common classification in all groupings was Y02E, which represents, reduction of greenhouse gas emissions related to energy generation, transmission, or distribution, or related to turbines, engines, pumps, transport, mechanical elements, biotechnology, thermal processes and apparatus, semiconductors, electrical machinery, energy, apparatus, and basic materials chemistry. In addition, there were other relationships such as metallurgy and materials with Y02P (climate change mitigation technologies in the production or processing of goods), environmental technology with Y02C (capture, storage, sequestration or, disposal of greenhouse gases), and civil engineering with Y02A (technologies for adaptation to climate change).

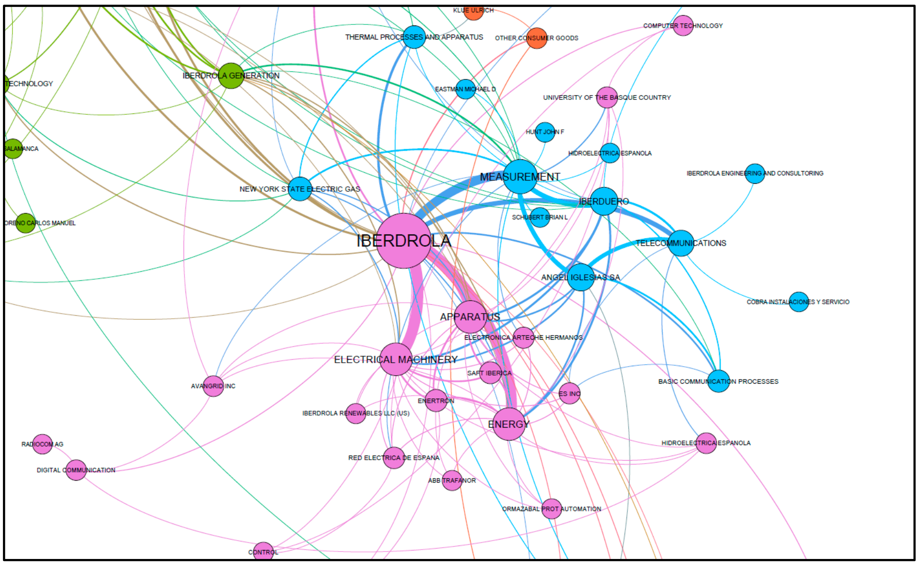

Figure 19. Zoom 2 of the network linking assignees and technical domains.

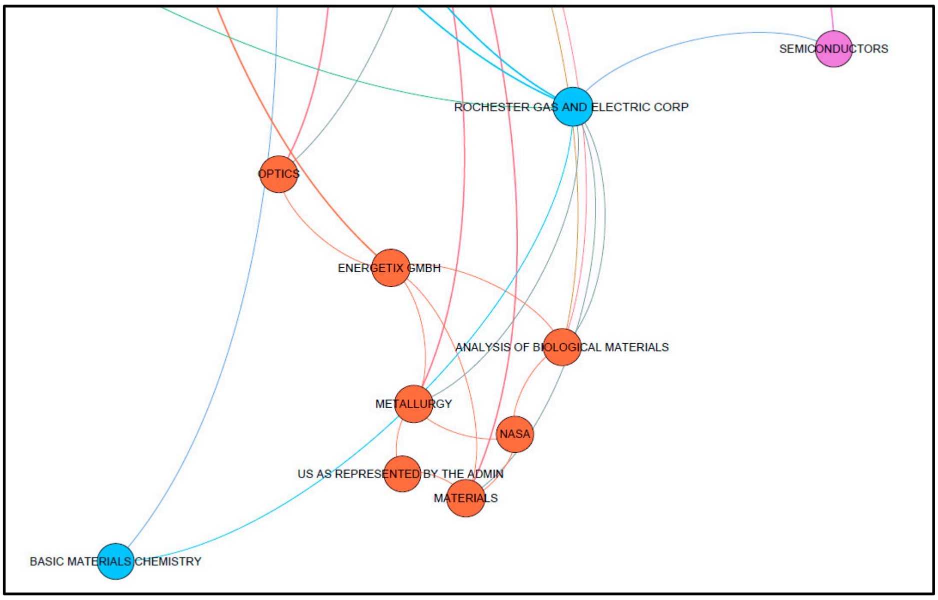

Figure 20. Zoom 3 of the network linking assignees and technical domains.

In order to identify collaborations between assignees within a technological development framework based on sustainability criteria, such as technological developments that aim to mitigate climate change, the network of relationships between assignees and CPCs (Y02) was carried out (see Figure 22). Six clusters were defined, and in the biggest one Iberdrola shared ownership of patents with Rochester Gas and Electric, Energetix, Nac Uranio, Tecnaton, the Higher Council of Scientific Research, and Iberdrola Nuclear Generation. A second cluster was led by Iberdrola Engineering and Construction and related to Iberdrola Renewables Spain and Carlos Manuel Padilla. Iberdrola Generation formed the third cluster together with the Polytechnic University of Madrid. The other three small clusters linked Iberdrola with Saft Iberica, New York State Gas and Electric, and Iberduero.

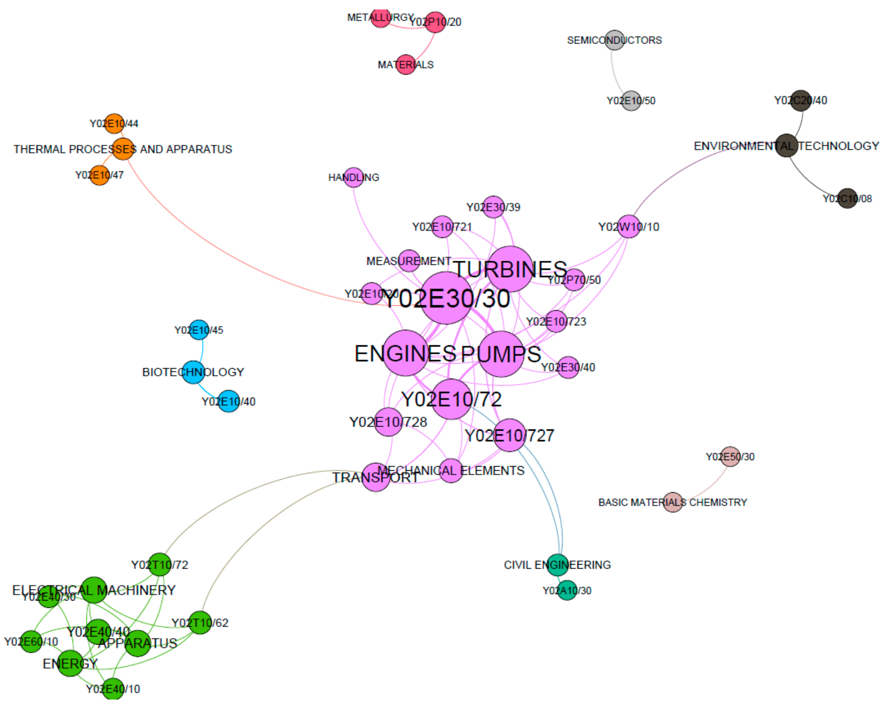

Figure 21. Network linking technical domains with Y02 code.

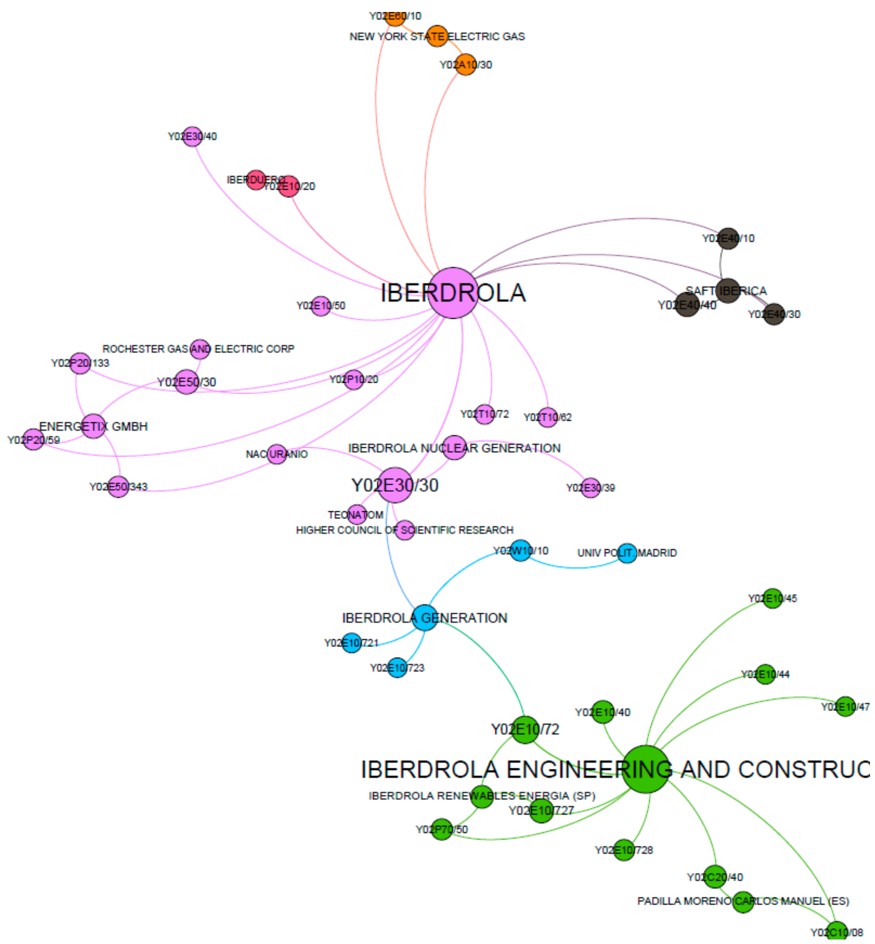

Figure 22. Network linking Assignees with Y02 code.

Once Iberdrola's collaborative relationships for its technological development in different technical domains were analyzed and identified, it was important to determine how the company had evolved in its technical work areas. To this end, the profile of the patents was analyzed by priority year and CPC code. As shown in Figure 23, the number of patents in which Iberdrola participated started to regain importance (after some relatively unproductive years at the beginning of the decade) from the year 2007–2008, emphasizing its wide technical diversification, especially in the year 2015, which implied greater collaborative diversification, and the year 2012, as a more productive year but with a greater concentration of technological fields. Regarding CPC Y02, it is important to highlight the importance it acquired in the last 10 years, directing innovative efforts towards technologies that prevent climate change.

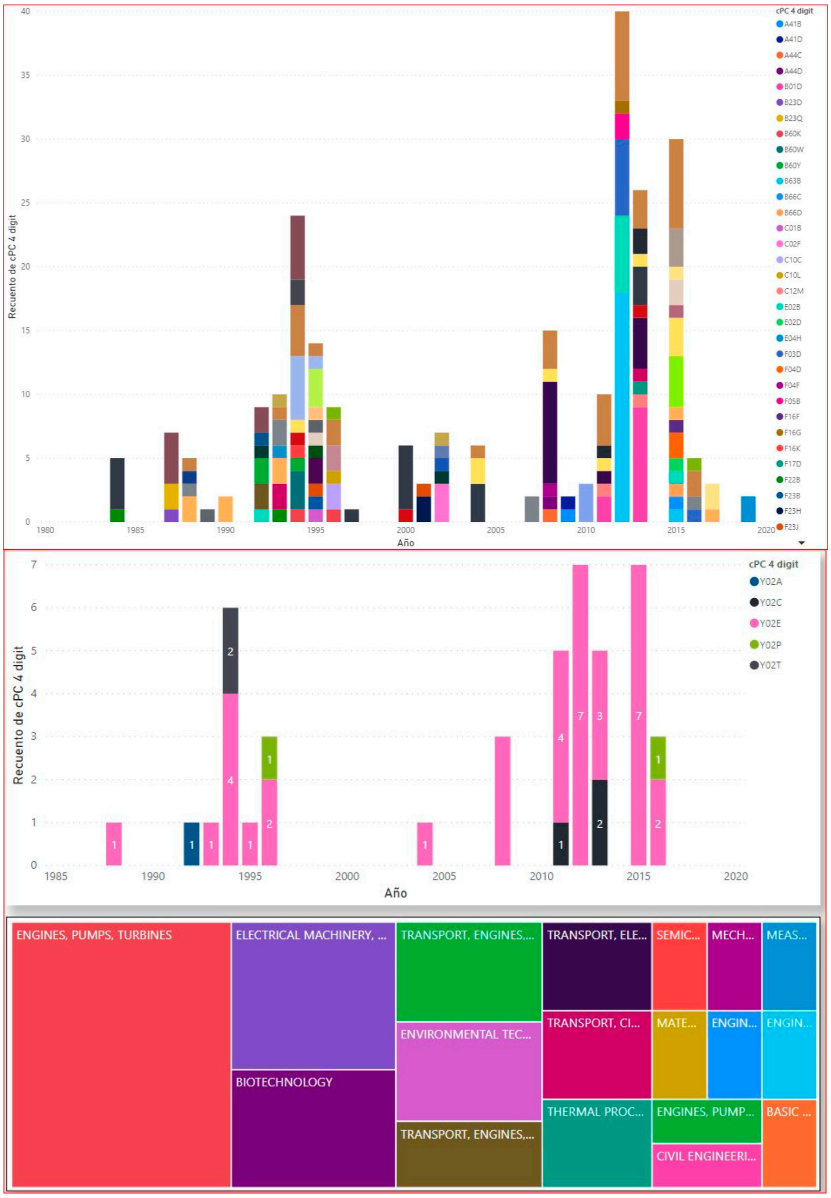

Figure 23. Iberdrola's patents profile by priority year and CPC code.

3.3. *A Sustainable Business Model Innovation*

The change in direction of Iberdrola's strategy towards an innovation management model based on the OI paradigm denoted a significant increase in its research, and technological development resulted in a collaborative way, as this research work shows. However, could it be said that this strategic change had an effect on the company's reputation? A company's reputation, being intangible, is very difficult to quantify. Nonetheless, there are various ways to measure it. One of the most established measures of reputation is ranking by media, such as Fortune, which is widely used by the scientific community to measure the link between reputation and other strategic variables [28]. One of the attributes used by Fortune [50] is long-term value creation that integrates financial, social, and environmental values to establish a sustainable business model. In addition, different studies confirm that companies with good performance in environmental, social, and governance (ESG) issues boast superior financial performance [29,51]. According to Schoenmaker and Schramade [29], a qualitative and quantitative evaluation of the ESG issues to be analyzed makes it possible to ascertain the financial impact it produces. As Figure 24 shows, the financial impact of the qualitative and quantitative information on ESG is measured through sales growth. In the case of innovation management (as an ESG issue), qualitative information about the innovation process is established and the quantitative information measures the expenditure in R&D, and consequently the financial impact indicator is established in the increase of sales. If we turn to the company Iberdrola, the creation of long-term value of innovation management is qualitatively focused on the OI perspective.

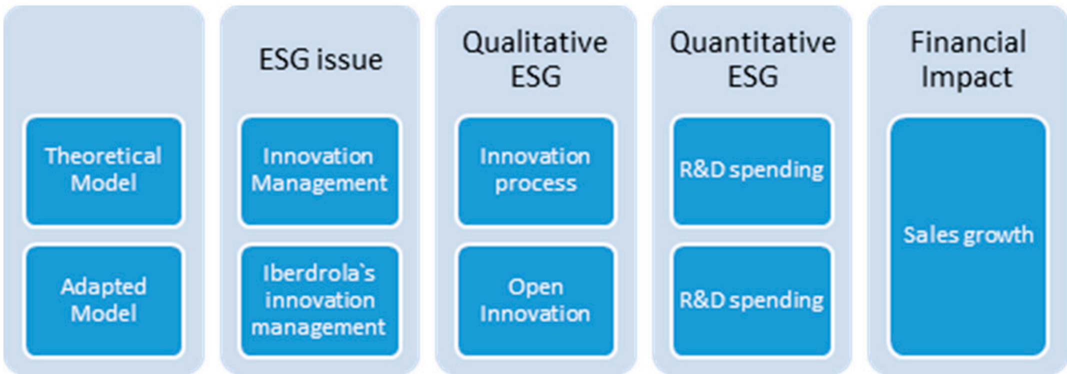

Figure 24. The financial impact of the qualitative and quantitative information about ESG issues. Adapted from Schoenmaker and Schramade [29].

Therefore, if we consider long-term value creation as an attribute that allows us to measure the reputation of the company Iberdrola and, in turn, innovation management as the material ESG issue to measure, then the measurement is carried out qualitatively through an OI perspective analyzed through the indicator based on the company's scientific development and quantitatively through R&D expenditure. The financial impact of the action taken was measured through the company's sales (as shown in Figure 24). This cause–effect relationship is represented graphically in Figure 25, from 2010 when the company Iberdrola received certification in R&D management systems. Iberdrola's scientific development generated an average of 23 publications per year in the last 10 years and, as a result of the study carried out, the development approach was collaborative, mainly with universities and research centers. In addition, R&D expenses increased in recent years. The financial impact of both are reflected in sales, which indicate an increase in sales of about EUR 6 billion between 2010 and 2019. Therefore, the implementation of the OI perspective can be considered a key element in Iberdrola's innovation system, boosting relations between universities and institutions, among others, and having a positive impact on the company's sales results. In addition, within the Fortune Global 500 [52], Iberdrola ranks at number 303.

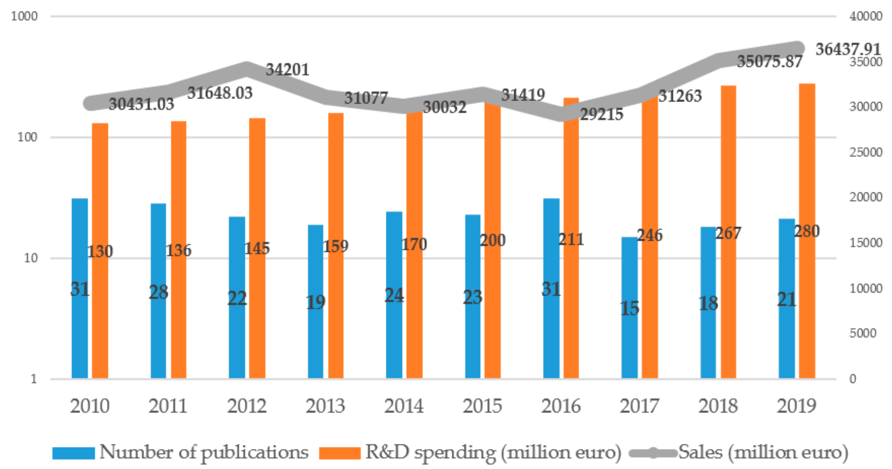

Figure 25. Number of publications, R&D spending, and sales of Iberdrola (2010–2019). Data on R&D spending and sales obtained from Iberdrola's annual reports [53].

4. Discussion and Conclusions

The results show that the company Iberdrola has always valued the promotion of scientific development and, therefore, its relationship with the scientific community, becoming a strategic line to follow and with further importance since 2005. As with its technological path, after a halt in the early 2000s, the company was able to recover its inventions and diversify its fields of action after 2008.

Iberdrola's first sustainability report was written in 2004 [54], and with it, the beginning of its commitment to a model of sustainable growth and respect for the environment, changing its profile to that of an energy company with corporate social responsibility. In addition, since 2013 Iberdrola has reinforced this line by implementing sustainable management policies [55], complementing other previous policies associated with climate change and the environment [56,57]. In the results of the study, the analysis of the research terms establishes 2009 as the first time that the term "OI" appears in Iberdrola's scientific publications. This was the year in which Tejedor-Escobar and Martinez-Cid [24], through their publication, introduced the scientific community to the new system of R&D management and innovation and collaboration management, known as innovation network, which Iberdrola launched in order to develop and promote a culture of knowledge. From that year onward, the number of publications in co-authorship with Iberdrola increased, remaining constant until now and investigating certain areas related to management (management of information, business schools, and sustainability). With this, the company Iberdrola chose to strengthen its innovation policies, making OI a strategic axis to carry out innovative and sustainable projects through collaboration with universities and other institutions [27]. This is corroborated by the network analysis carried out in the study. Iberdrola has a solid, sound network of scientific collaboration with other institutions, its main links being universities and research centers in Spain, while also maintaining the same strength of collaboration with international sections of universities and international research centers, creating a network that has nodes in America, Asia, and Europe. Moreover, it should be noted that both national and international companies direct their efforts towards collaborative scientific development, indicating an advancement in business management of open and collaborative innovation.

With regard to patents, between the years 2000 and 2006 there was a slowdown in the number of inventions, suggesting that this may be due to a change in the company's strategic approach, with the development of technological innovations losing strength. However, from 2007 to 2008 Iberdrola once again promoted technological development, becoming involved in different technical domains and, therefore, promoting the network of collaborations. Contrary to what happens in scientific development, this network of collaborations is mainly formed by companies that share the ownership and future commercial development of the patent with Iberdrola. All this justifies the correct implementation of strategic policies that value collaborative work as an improvement of the innovation system. As for the sustainability approach, the definition of the CPC codes makes it possible to identify innovations or technological developments that mitigate climate change, such as Y02 [58,59]. Therefore, the results related to the number of patents classified in this technical area validate the approach to management and sustainable development that Iberdrola has been promoting since 2004.

This research study confirms that the strategic change of management set by Iberdrola, focusing its business management on a new approach based on OI, has enabled it to attain a good situation in its contribution to both scientific and technological development, thanks to collaborations with various universities, research centers, and companies that are committed to sustainable and open innovation. This approach has resulted in an increase in its reputation as a sustainable company. Therefore, the strategic approach towards a sustainable business model promotes the implementation of innovative processes open to collaboration with other entities, which produce a positive financial impact on the company.

Author Contributions: Conceptualization, I.A.-M., N.P.-G. and R.M.R.-B.; methodology, I.A.-M.; software, I.A.-M., N.P.-G. and R.M.R.-B.; validation, I.A.-M., N.P.-G. and R.M.R.-B.; formal analysis, I.A.-M. and N.P.-G.; investigation, I.A.-M., N.P.-G. and R.M.R.-B.; resources, I.A.-M.; data curation, N.P.-G.; writing—original draft preparation, I.A.-M. and N.P.-G.; writing—review and editing, I.A.-M., N.P.-G. and R.M.R.-B.; visualization, I.A.-M.; supervision, R.M.R.-B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chesbrough, H.W. The Era of Open Innovation MITSloan Management Review. *Mit Sloan Manag. Rev.* **2003**, *44*, 35–41.
2. Randhawa, K.; Wilden, R.; Hohberger, J. A Bibliometric Review of Open Innovation: Setting a Research Agenda. *J. Prod. Innov. Manag.* **2016**, *33*, 750–772. [CrossRef]
3. Gambardella, A.; Raasch, C.; Von Hippel, E. The user innovation paradigm: Impacts on markets and welfare. *Manag. Sci.* **2017**, *63*, 1450–1468. [CrossRef]
4. Hoffmann, V.; Probst, K.; Christinck, A. Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? *Agric. Hum. Values* **2007**, *24*, 355–368. [CrossRef]
5. Meissner, D.; Shmatko, N. Integrating professional and academic knowledge: The link between researchers skills and innovation culture. *J. Technol. Transf.* **2019**, *44*, 1273–1289. [CrossRef]
6. Smart, P.; Holmes, S.; Lettice, F.; Pitts, F.H.; Zwiegelaar, J.B.; Schwartz, G.; Evans, S. Open Science and Open Innovation in a socio-political context: Knowledge production for societal impact in an age of post-truth populism. *RD Manag.* **2019**, *49*, 279–297. [CrossRef]
7. Bogers, M. The open innovation paradox: Knowledge sharing and protection in R&D collaborations. *Eur. J. Innov. Manag.* **2011**, *14*, 93–117. [CrossRef]
8. Bagherzadeh, M.; Markovic, S.; Cheng, J.; Vanhaverbeke, W. How does Outside-In Open Innovation Influence Innovation Performance? Analyzing the Mediating Roles of Knowledge Sharing and Innovation Strategy. *IEEE Trans. Eng. Manag.* **2019**, 1–14. [CrossRef]
9. Abreu, A.; Urze, P. An approach to measure knowledge transfer in open-innovation. In Proceedings of the ICORES 2014—3rd International Conference on Operations Research and Enterprise Systems, Angers, France, 6–8 March 2014; pp. 183–189. [CrossRef]
10. Gnyawali, D.R.; Park, B.J. Co-opetition between giants: Collaboration with competitors for technological innovation. *Res. Policy* **2011**. [CrossRef]
11. Norberg-Bohm, V. Creating Incentives for Environmentally Enhancing Technological Change. *Technol. Forecast. Soc. Chang.* **2000**, *65*, 125–148. [CrossRef]
12. Lopes, C.M.; Scavarda, A.; Hofmeister, L.F.; Thomé, A.M.T.; Vaccaro, G.L.R. An analysis of the interplay between organizational sustainability, knowledge management, and open innovation. *J. Clean. Prod.* **2017**, *142*, 476–488. [CrossRef]

13. García-Álvarez, M.T. Analysis of the effects of ICTs in knowledge management and innovation: The case of Zara Group. *Comput. Hum. Behav.* **2015**, *51*, 994–1002. [CrossRef]
14. Andersen, M.M.; Foxon, T. The Greening of Innovation Systems for Eco-Innovation—Towards an Evolutionary Climate Mitigation Policy. In Proceedings of the DRUID Summer Conference 2009 on Innovation, Strategy and Knowledge, Bologna, Italy, 24–25 September 2009.
15. Marchi, V. De Environmental innovation and R & D cooperation: Empirical evidence from Spanish manufacturing firms. *Res. Policy* **2012**, *41*, 614–623. [CrossRef]
16. Faisal, M.N. Analysing the barriers to corporate social responsibility in supply chains: An interpretive structural modelling approach. *Int. J. Logist. Res. Appl.* **2010**, *13*, 179–195. [CrossRef]
17. Harrison, R.; Newholm, T.; Shaw, D. *The Ethical Consumer*, 1st ed.; SAGE Publications: London, UK, 2005; ISBN 978-1-4129-0353-0.
18. McPhee, W. A new sustainability model: Engaging the entire firm. *J. Bus. Strategy* **2014**, *35*, 4–12. [CrossRef]
19. Fukuyama, M. Society 5.0: Aiming for a New Human-centered Society. *Jpn. Spotlight* **2018**, *27*, 47–50.
20. UNESCO Moving Forward the 2030 Agenda for Sustainable Development—UNESCO Biblioteca Digital. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000247785 (accessed on 15 April 2020).
21. Shiroishi, Y.; Uchiyama, K.; Suzuki, N. Society 5.0: For Human Security and Well-Being. *Computer* **2018**, *51*, 91–95. [CrossRef]
22. Fukuda, K. Science, technology and innovation ecosystem transformation toward society 5.0. *Int. J. Prod. Econ.* **2019**, 107460. [CrossRef]
23. Salimova, T.; Guskova, N.; Krakovskaya, I.; Sirota, E. From industry 4.0 to Society 5.0: Challenges for sustainable competitiveness of Russian industry. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, *497*. [CrossRef]
24. Tejedor-Escobar, E.; Martínez-Cid, P.M. Red de Innovación de Iberdrola. *Dyna* **2009**, *84*, 470–480.
25. Iberdrola: The Utility of the Future—Iberdrola. Available online: https://www.iberdrola.com/home (accessed on 13 October 2020).
26. Iberdrola Sustainability. Available online: https://www.iberdrola.com/sustainability (accessed on 15 October 2020).
27. Iberdrola. Open Innovation and Partnerships—Iberdrola. Available online: https://www.iberdrola.com/innovation/open-innovation-partnerships (accessed on 13 October 2020).
28. Chun, R. Corporate Reputation: Meaning and Measurement. *Int. J. Manag. Rev.* **2005**, *7*, 91–109. [CrossRef]
29. Schoenmaker, D.; Schramade, W. Investing for long-term value creation. *J. Sustain. Financ. Investig.* **2019**, *9*, 356–377. [CrossRef]
30. van Nunen, K.; Li, J.; Reniers, G.; Ponnet, K. Bibliometric analysis of safety culture research. *Saf. Sci.* **2018**, *108*, 248–258. [CrossRef]
31. Ospina-Mateus, H.; Quintana Jiménez, L.A.; Lopez-Valdes, F.J.; Salas-Navarro, K. Bibliometric analysis in motorcycle accident research: A global overview. *Scientometrics* **2019**, *121*, 793–815. [CrossRef]
32. Cobo, M.J.; López-Herrera, A.G.; Herrera-Viedma, E.; Herrera, F. Science mapping software tools: Review, analysis, and cooperative study among tools. *J. Am. Soc. Inf. Sci. Technol.* **2011**, *62*, 1382–1402. [CrossRef]
33. Madani, F.; Weber, C. The evolution of patent mining: Applying bibliometrics analysis and keyword network analysis. *World Pat. Inf.* **2016**, *46*, 32–48. [CrossRef]
34. Ugolini, D.; Bonassi, S.; Cristaudo, A.; Leoncini, G.; Ratto, G.B.; Neri, M. Temporal trend, geographic distribution, and publication quality in asbestos research. *Environ. Sci. Pollut. Res. Int.* **2015**, *22*, 6957–6967. [CrossRef]
35. Medeiros, G.; Binotto, E.; Caleman, S.; Florindo, T. Open innovation in agrifood Chain: A systematic review. *J. Technol. Manag. Innov.* **2016**, *11*, 108–116. [CrossRef]
36. Lopes, A.P.V.B.V.; de Carvalho, M.M. Evolution of the Open Innovation Paradigm: Towards a Contingent Conceptual Model. *Technol. Forecast. Soc. Chang.* **2018**, *132*, 284–298. [CrossRef]
37. de Paulo, A.F.; Carvalho, L.C.; Costa, M.T.G.V.; Lopes, J.E.F.; Galina, S.V.R. Mapping Open Innovation: A Bibliometric Review to Compare Developed and Emerging Countries. *Glob. Bus. Rev.* **2017**, *18*, 291–307. [CrossRef]
38. de Paulo, A.F.; Oliveira, S.V.W.B.; Porto, G.S. Mapping impacts of open innovation practices in a firm competitiveness. *J. Technol. Manag. Innov.* **2017**, *12*, 108–117. [CrossRef]
39. Della Corte, V.; Del Gaudio, G.; Sepe, F.; Sciarelli, F. Sustainable tourism in the open innovation realm: A bibliometric analysis. *Sustainability* **2019**, *11*, 6114. [CrossRef]

40. Chaurasia, S.S.; Kaul, N.; Yadav, B.; Shukla, D. Open innovation for sustainability through creating shared value-role of knowledge management system, openness and organizational structure. *J. Knowl. Manag.* **2020**. [CrossRef]
41. Elsevier. *Scopus: Content Coverage Guide*; Elsevier: Amsterdam, The Netherlands, 2017; pp. 1–28.
42. Martín-Martín, A.; Orduna-Malea, E.; Thelwall, M.; Delgado López-Cózar, E. Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. *J. Informetr.* **2018**, *12*, 1160–1177. [CrossRef]
43. Orduna-Malea, E.; Ayllón, J.M.; Martín-Martín, A.; Delgado López-Cózar, E. Methods for estimating the size of Google Scholar. *Scientometrics* **2015**, *104*, 931–949. [CrossRef]
44. Ortega, J.L. *Academic Search Engines: A Quantitative Outlook*; Elsevier: Amsterdam, The Netherlands, 2014; ISBN 978-1-78063-472-2.
45. PatSeer Features of Patent Search and Analysis Software PatSeer. Available online: https://patseer.com/features-patent-search-analysis-software/ (accessed on 19 October 2020).
46. Search Technology. The Vantage Point. Available online: https://www.thevantagepoint.com/ (accessed on 15 July 2020).
47. Bastian, M.; Heymann, S.; Jacomy, M. Gephi: An open source software for exploring and manipulating networks. BT—International AAAI Conference on Weblogs and Social. In Proceedings of the International AAAI Conference on Weblogs and Social Media, San Jose, CA, USA, 17–20 May 2009; pp. 361–362.
48. Pikatza, N.; Álvarez-Meaza, I.; Río-Belver, R.M.; Cilleruelo, E. *Strategic Open Innovation Model: Mapping Iberdrola Network*; Editorial Universitat Politècnica de València: Valencia, Spain, 2020; pp. 133–142, ISBN 978-84-9048-832-4.
49. Sinha, M.; Pandurangi, A. *Guide to Practical Patent Searching and How to Use PatSeer for Patent Search and Analysis*, 2nd ed.; Gridlogics Technologies Pvt. Ltd.: Pune, India, 2016.
50. Reputation X How Fortune Ranks the World's Most Admired Companies. Available online: https://blog.reputationx.com/fortune-rankings (accessed on 23 November 2020).
51. Schramade, W. Bridging Sustainability and Finance: The Value Driver Adjustment Approach. *J. Appl. Corp. Financ.* **2016**, *28*, 17–28. [CrossRef]
52. Fortune Iberdrola|2020 Global 500. Available online: https://fortune.com/company/iberdrola/global500/ (accessed on 26 November 2020).
53. Iberdrola Annual Reports—Iberdrola. Available online: https://www.iberdrola.com/shareholders-investors/annual-reports (accessed on 28 November 2020).
54. Iberdrola. *Sustainability Report*; Iberdrola: Bilbao, Spain, 2017; p. 346.
55. Iberdrola Sustainable Management Policy. Available online: https://www.iberdrola.com/corporate-governance/corporate-governance-system/corporate-policies/sustainable-management-policy (accessed on 15 October 2020).
56. Iberdrola Policy against Climate Change. Available online: https://www.iberdrola.com/corporate-governance/corporate-governance-system/corporate-policies/policy-against-climate-change (accessed on 15 October 2020).
57. Iberdrola Environmental Policy. Available online: https://www.iberdrola.com/corporate-governance/corporate-governance-system/corporate-policies/environmental-policy (accessed on 15 October 2020).
58. EPO&UPSTO Cooperative Patent Classification—About CPC. Available online: https://www.cooperativepatentclassification.org/about (accessed on 20 October 2020).
59. Veefkind, V.; Hurtado-Albir, J.; Angelucci, S.; Karachalios, K.; Thumm, N. A new EPO classification scheme for climate change mitigation technologies. *World Pat. Inf.* **2012**, *34*, 106–111. [CrossRef]