The impact of the Paris Agreement on R&D expenditure in the electricity sector[1]

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Abstract

European Union member countries was signed the 2030 Climate and Energy Framework Agreement on October 24, 2014. This framework brings with it changes in the expectations of energy consumers and producers, which opens new avenues of research. With the imposition of targets to be achieved by 2030 under the Paris Agreement signed in 2014, it is expected that R&D spending on energy companies will increase to reach 27% of renewable energy consumption, reduction of emissions of dioxide of carbon in at least 40% and to improve energy efficiency.

This study analyzes the behavior that companies related to the electricity sector had before and after this Agreement through the model of differences in differences, comparing companies with headquarters in European Union countries and the other countries in Europe, having in attention the periods before and after 2014. This method generates evidence that this Agreement, through the OLS, FE and RE models, did not bring an increase in R&D expenditures in companies related to the electricity sector in the countries of the European Union, but rather the opposite, a reduction. Therefore, it will be necessary to create more incentives for companies to increase R&D expenditure faster and faster in order to achieve the targets of the Paris Agreement.

Keywords: Paris Agreement, R&D expenditures, difference in difference model.

Analysis of the impact of the Paris Agreement on R&D expenditure on electricity sector

1. Introdution

The Agreement was signed in 2014 by European Union (EU) countries. The agreement was three main objectives to achieve until 2030: to reduce at least 40% the greenhouse gas emissions by 2030 at levels of 1990; to reach a target of at least 27% of renewable energy consumed in the EU until 2030; and to improve energy efficiency through possible amendments to the energy efficiency directive (European Council, 2014). To achieve these goals, it will be necessary to develop new technologies and/or improve the energetic efficiency of the technologies already in place. In both cases, implementation will, likely, only be possible through an increase in research and development (R&D) expenditures.

Following (Franzen, Rodgers, & Simin, 2007) (Lee & Lee, 2013) the expenses with R&D have been increasing over the years because companies want to be competitive and for that reason they have to modernize and search for innovation in order to gain competitive advantages against the opponents. One way of the companies obtain competitive advantages is through the development of new technologies and/or increase in competitiveness through efficiency gains in existing technologies. For this to happen, companies should invest more in R&D (Peteraf, 1993).

The purpose of this work is to check if energy companies increased the expenditure in R&D after the Paris Agreement was signed, to assess if companies in Europe have the same behavior in what concerns R&D expenses when compared with EU companies, knowing in advance that the cost of producing renewable energy is higher than the cost of fossil energy. In addition, sustainable economies depend on the reduction of greenhouse gas emissions, which should be possible through technology and energy consumption with a minor environmental impact (Fernández Fernández, Fernández López, & Olmedillas Blanco, 2018). Considering the factors mentioned above, in order to demonstrate whether there has been an evolution in R&D expenditures, the difference in difference (DiD) model will be used because two dimensions are being analyzed at the same time. In another words, a comparative analysis of companies before 2014 and after 2014 and another comparative analysis between companies based in the countries of the European Union and countries with headquarters outside the European Union.

Nowadays, a significant part of the developed world is placing a strong emphasis on the future of new generations, considering that the world population continues to grow, especially in developing countries, and the energy sector has an important role in the new challenges both economic, geopolitical, technological and environmental. Due to the future of the coming generations, according to (Glavas & Mish, 2015), there is a need for sustainable development in the triple bottom line approach, that is, social development, economic development, and sustainable development.

The present paper is organized as follows: the first section is dedicated to the literature review on factors that can condition R&D expenditures in electricity industry, followed by a presentation of the methodology and sample selection and description. The empirical results and their implications are discussed afterwards. Finally, the conclusions, recommendations and limitations of the study are presented.

2. Literature review

Greenhouse gas emissions have followed the trend of increase in energy consumption. Yet, it is possible to invert that trend through energy efficiency improvements through technological development and innovations in the companies (Costa-Campi, García-Quevedo, & Trujillo-Baute, 2015). So, R&D expenses could be transformed into energy savings and, as a consequence, facilitate the reduction of CO_2 emissions, based on low-carbon technology (Gu & Wang, 2018).

Another way of reducing CO_2 emissions is by increasing the use of renewable energies (Sim, 2018). The government's policy aims can influence the speed of development of new renewable energies (Kim, Lee, & Park, 2014). However, in countries were the petroleum refining sector has a large expression, governmental policies for renewable energy R&D investment have a negative relationship but nevertheless there is a positive relationship between the fossil fuels and the R&D investment which can be explained by the search of new forms of extraction of fossil fuels (Sun & Kim, 2017).

Based on the report of (IEA, 2017) in 2015 just 18% of world primary energy supply is non fossil, and due the growth of the demand from fossil fuels around the world the CO_2 emissions in this century don't stop growth, been the fossil fuels the main contributor to green gas emissions (Zhao & Luo, 2017).

There are several factors that can condition R&D expenditure in the companies such as the type of management, the strategy of the company, the types of incentives, the financing, the budget (Heidenberger, Schillinger, & Stummer, 2003), organizational network, profitability of returns (J. C. Lin & Wang, 2016), the growth of the market (Brown, Martinsson, & Petersen, 2016) and pressure for sustainable economies with an energy sector in a more efficient mode of production and consumption of energy. This would be the smartest approach in future global efforts to save energy according to (Kahouli, 2018).

2.1 Type of management of companies

The type of management have been studied to involve several conditions and effects on board and ownership structure when the institutional investors have a significant weight in capital and the management structure has a positive effect on R&D expenditure (Baysinger, Kosnik, & Turk, 1991). The separation between ownership and control created by the separation between capital holders and management increases the potential conflicts of interest (Adams & Ferreira, 2007), since capital holders seek to maximize their long-term profit while managers have a shorter-term view seeking to deliver good results in the short term by disrupting the medium- and long-term business (Osma, 2008) (Driver & Guedes, 2012). Managers are conditioned by the prestige, the security in their personal interests (Burgstahler & Dichev, 1997). Because R&D investment does not have short term returns and the success is not guaranteed, managers often choose not to invest in this area, however, from the point of view of capital holders from R&D investment, although risky, it is seen as an opportunity of improve the company's performance in the future as well as a diversification strategy within the company itself (Coad & Rao, 2010).

In listed companies, large groups of capital holders tend to have a greater focus on the performance of managers, seeking to align their decisions in order to achieve better long-term performance by encouraging investment in R&D (Baysinger et al., 1991).

Institutional investors are criticized, often, due to their own shorter-term view and that way they force managers to have the same kind of thinking which will have impact in the investment decision (Baysinger et al., 1991). In the opposite side, (Bushee, 2001) (Dikolli, Kulp, & Sedatole, 2009) defend that institutional investors have a long-term view which allows managers not to feel the pressure of obtain results in the short term

but have an investment view of long term which provides for a more sustainable decision. Other studies such as (Bushee, 1998) and (L. Lin, 2016) show us that companies in which the majority of the capital is owned by institutional investors, the managers don't have so much propensity to reduce the R&D expenditures in order to obtain better results in the short term, but the study of (Driver & Guedes, 2012) did not find evidence that the bigger institutional investors increase the R&D expenditures. (Bushee, 2001) mentions the fact that there exist two kinds of institutional investors, the first one is for example the banks who have a vision of short term and just have returns in reduced time, and the second type of institutional investors which hold a large proportion of capital and want to have sustainable decisions of investments and have a long-term view, which means there is no reduction of R&D expenditures with the goal of obtain good results in the sort-term. (Bernard & Thomas, 1989) (Lev, Sarah, & Sougiannis, 2005) (L. Lin, 2016) mention that R&D expenditures are one way of the managers accomplishing change in the results through a more or less conservative financial register depending on the interests of managers.

The introduction of independent directors has meant that earnings management is less manipulated and that the independence of managers based on their technical expertise has the capacity to recognize opportunities to reduce R&D costs and are efficient in carrying out these constraints, so that the number of independent managers is increasing in companies (Osma, 2008). The board members are key players in companies because they are the ones who define the strategies of the companies and verify their implementation by the managers, ensuring that they meet the interests of the board (Baysinger et al., 1991). However, managers, as they have greater inside knowledge compared with the board, in particular the external board, use this advantage to convince the board what the optimal R&D cuts are, even if they are not (Osma, 2008). The pressures that exist with incentive policies to achieve results mean that, in the short term, management is aware of all opportunities to reduce costs and as such there is no longer a vision and commitment with the long term (Dikolli et al., 2009). Hence, (external) board members have to realize when this happens and seek to counteract management by not allowing them to cut back on R&D (Adams & Ferreira, 2007). Managers, in turn, will want to contradict by saying that board members should delegate this type of decision to managers because they have better knowledge on the subject matter and the board should focus more on monitoring

rather than advice (Osma, 2008) and because these managers are independent board members (external) are afraid to share all the information (Adams & Ferreira, 2007).

The structure of financial management affects the assessment to capital market and investments in R&D (Chung, Wright, & Kedia, 2003). The same authors add the evaluation of the company's capital market and investments in R&D are dependent on the composition of the administration (board) and also the analysts who follow the company, but not on the institutional owners. Capital expenditures and R&D alone do not add value to companies because these same expenses may not be used most efficiently and profitably (Chung et al., 2003). This is due to the fact that when unmonitored and controlled managers tend to make less-than-efficient investment decisions in order to maximize their own interests to the detriment of stakeholder interests (L. Lin, 2016). Therefore, it is not clear that the level of capital and R&D expenditure alone is not the best way to measure the effect of these expenditures directly on the value of the company, and therefore the purpose of such investment should be taken into account, such as the correct use, use in better, cheaper or innovative products or processes (L. Lin, 2016). There may also be control of business management by outsiders such as financial analysts, external directors and institutional investors help monitor management performance and thus affect the market valuation of capital and R&D investments (Chung et al., 2003). With more monitoring it will make the problems of agency theory decrease (L. Lin, 2016).

2.2 Business strategy

Another point is the strategy of the company and the way it can obtain advantages faced to the competitors. According to (Peteraf, 1993), the competitive advantage is the ability to create economic value above that created by its competitors (break-even) in the market. R&D expenditures by companies aim to achieve competitive advantages over their competitors and have been growing in the two last decades (Lee & Lee, 2013). The sustainable competitive advantage is obtained when there are differentiating capacities in its possession, being possible to identify the internal sources that potentially result in a competitive advantage using Resource Based Theory (Barney & Wright, 1997). What's behind of these differentiating capacities are considered intangible assets that can be obtained through patents, licenses, reputation and/or know-how, and the latter were considered by executives as having the most significant weight for business success (R. Hall, 1992). To do this, each resource must have four characteristics: it must be valuable

exploring opportunities or neutralizing threats in the market where it operates, it must be rare among current and incumbent competitors, it must be imperfectly imitable either because of cost or complexity in its design and production and has to be explored by the organization, and for this to be properly prepared to draw up appropriate strategies (Barney, 1991). As such, it is necessary for companies to define their strategies in relation to R&D expenditures, with R&D expenditures usually not constant over time (Mudambi & Swift, 2011). The volatility of R&D spending means that this is a proactive management of R&D investment. This is consistent with an equilibrium model where there is investment in R&D, where shocks are induced by reactions to external turbulence. Thus, large fluctuations in R&D investment are associated with higher corporate growth (Mudambi & Swift, 2011). However, the same authors point out that this evidence is weak in companies with high business diversification, and negative in small firms as well as slow process industries (slow product obsolescence).

Two types of exploration of the strategies are considered, the first one was to exploit the skills in which the company already has a knowledge that is a competitive advantage (Barney & Wright, 1997). The other type of exploration has to do with exploiting the attempt to obtain new knowledge (Mudambi & Swift, 2011). Companies that can have both types of exploration are the ones that have a better perform because they are able to exploit to the maximum the value of existing assets and capabilities as well as to invest resources in the search for new opportunities. The ability to invest in these two types of exploration is typical of firms that have high volatility in R&D expenditure over time. The results of the study (Mudambi & Swift, 2011) hinted that companies with higher volatility of R&D spending are shifting from one type of exploration to the other, creating disruption in the R&D process and may lead more creative investors of these companies lose their motivation.

2.3 Financing

In order to have a high operational cash flow, small innovation companies traditionally have higher capital costs, of external financing due to asymmetric information, which can however be mitigated by the existence of venture capital (B. Hall & Lerner, 2009). The same is not clear in large R&D companies whether capital costs are high. However, in large companies there is a preference for internal capital in R&D investment, managing its cash flow in order to guarantee the financing, and reducing the adverse selection problem. In less developed markets, in terms of the venture capital market, there are still

no limits to the granting of credit for investment in R&D (B. Hall & Lerner, 2009). In practice, according to these authors, fifty percent or more of R&D expenditures are wages and salaries of highly qualified researchers and engineers. The main work of the R&D team is the creation of an intangible asset, the company's knowledge base, from which profits will be generated in the coming years. Once this knowledge is tacit, being embedded in the human capital of the company's employees, it may be lost if they leave the company or die (evanish).

A little further back in the R&D process is part of the funding of this research and development. For (Coad & Rao, 2010), the financing of R&D expenditures has several difficulties: firstly, the return of the funds invested in R&D is unknown both in terms of profitability and of the payout period. Secondly, due to the intangible nature of R&D investment, R&D projects have no guarantee of success (Bakker, 2013). Third, asymmetric information problems can arise if the investor has difficulty distinguishing good projects from bad ones or even if the company is wary of releasing detailed information about his R&D project (Guiso, 1998). Information asymmetries can be especially severe in the case of high-tech companies (Guiso, 1998). Fourth, moral hazard problems can be amplified by the uncertainty inherent in R&D projects (Bakker, 2013). Fifth, the possibility of technological by-products and imitation by rivals may discourage investment in R&D.

Concerns that there may be underinvestment in R&D by firms has become of political interest in relation to the dynamics and determinants of R&D expenditure and issues related to how R&D can be stimulated (González & Pazó, 2008). Thus, several forms of tax benefits have been introduced by governments in order to counteract this underinvestment in R&D. According to (Minniti & Venturini, 2017) here is a relationship between the labor productivity growth rate and the political R&D incentives, namely the R&D tax credit and state R&D funds. (Miremadi, Saboohi, & Jacobsson, 2018) mention the support of the State is critical to make R&D more effective.

2.4 Incentives

(Cheng, 2013) raises another issue related to R&D spending, how do managers not condition R&D expenditures on the remunerations/awards they give themselves? As a result, changes in R&D spending are positively associated with changes in rewards/compensation attributable to managers, particularly in two situations: the

manager is close to retirement age, that is, over the age of 63 (Cheng, 2013) and when the company has a decrease of the profits or presents losses (Bernard & Thomas, 1989) (Burgstahler & Dichev, 1997). R&D spending can be considered as a form of company growth as well as a source of competitive advantage (Mudambi & Swift, 2011). However, managers may be tempted to reduce R&D spending in order to achieve better short-term financial results, adjusting their R&D budgets in order to leverage corporate earnings, resulting in a not so good performance in the long term (Swift, 2013). Managers have incentives to reduce R&D spending in order to reverse poor performance, especially if the expected fall is small and therefore more likely to reverse these results (Burgstahler & Dichev, 1997). Then, according to the same authors, companies that maintain an availability of organizational flexibility are better able to finance emerging R&D projects, less likely to reduce R&D expenses to keep operating cash flow and, in turn, manage to create more value.

2.5 Budget and social networks

Budgeting decisions on R&D are extremely important for two reasons: short-term financial stability is a risk because R&D expenses can be sizable; on the other hand, if little is spent, it may undermine long-term competitiveness (Heidenberger et al., 2003). Therefore, an attempt should be made to find a model for assessing alternatives to budgeting in terms of financial developments, and the timing of the investment decision and the optimal level of investment in R&D are the main factors (Heidenberger et al., 2003). R&D project teams have to balance efficiency within the limits of the resources they have, so R&D performance is conditioned by internal social networks, by the existing technological constraints (Hung, 2017). (Koka & Prescott, 2008) have revealed that there are research groups (R&D) that are concentrated on specific research institutions or universities, indicating that being part of a high-density research network can produce exceptional R&D performance. As such, social networks and interpersonal skills interfere in the research team as well as in their performance so there are authors (Coleman, 1988) who claim that these social networks in a research team can be considered the social capital of a company. This type of social capital is a combination of innovation with transformation capacity and knowledge integration in a collaborative team (Hung, 2017). The social network influences the life of the researcher, his work and his emotional state and can also affect the atmosphere, communication and operational efficiency of an organization (Argyle 1998). Such networks can bring about sharing of

knowledge that will help communication and innovation in cases where such networks are closed (within the organization itself), being opportunities to explore technology, alliances, learning and development. The transfer and sharing of knowledge and the existence of an organizational network influence the innovative performance of this organizational network (Heidenberger et al., 2003). Individuals with a relatively high density of technology ties tend to be seen as assuming roles in the mobilization of R&D resource allocation (Sutanto, Tan, Battistini, & Phang, 2011). Organizations with strong technological ties within the technological community associated with it, will tend to have a greater evolution, to have new ideas and innovations and will be better able to understand technological developments and market opportunities (Rhee & Ji, 2011). Innovation performance comes not only from internal R&D processes but also the ability to discover, identify, absorb, transform and accumulate valuable external information. This is termed "absorption capacity" (Zahra & George, 2002).

2.6 Profitability

The financial constraints of firms' R&D intensity are seen as a discontinuity or suspension of R&D projects (Li, 2011). This increases the risk of the R&D intensity of companies and consequently has a higher R&D capacity, leading these companies to be the target of more acquisition proposals and, as a result, investors are at greater risk as well as financially constrained (J. C. Lin & Wang, 2016). This discontinuity or suspension of projects can mean a reduction in the value of the company since the probability that the company will be unable to finish its R&D project before its competitors, so the impact of the suspension of R&D funding can be damaging for the company. Thus, there is a strong relationship between financial constraints and the expected return on investment in R&D (Li, 2011).

Contrary to expectations, profit growth has little relation to R&D investment. But, however, R&D investment is related to sales and employment. A different view have presented (Klette & Griliches, 2000) claiming that the growth of the company depends on R&D and innovation spending. On the other hand (Kumar & Li, 2016) are of the opinion that technologically mature industries make capital investments with the purpose of converting the options of growth in assets, presenting a negative relation between the investment in capital and the yields of short-term. However, in many industries with huge potential for innovation, companies make capital investments to develop innovative capabilities to generate and commercialize potential future innovations, such as buying

and selling patents that can help business growth (Mudambi & Swift, 2014). Companies in industries focused in innovation, proactively use capital investment to facilitate the generation of new growth options by building innovative capacity (Pike, Ross, & Marr, 2005). (Lee & Lee, 2013) mention the number of energy patents have increasing in the last 20 years mainly ocean and geothermal technologies. In addition, investment in innovation capacity increases the expected revenue, allowing the company to makes sales based on the quality of the innovations, conditioned to its creation and development (Mudambi & Swift, 2014), being considered by (Coombs, 1996) that the intangible assets are one of the main drivers of innovation and organizational value.

2.7 Market Growth

Innovation and productivity growth are due to investment in R&D, but financing difficulties make this investment smaller than the optimal social level (González & Pazó, 2008), in particular in companies with higher technological intensity (Brown et al., 2017). -Several countries have tried to solve this problem through tax incentives and other policy initiatives to solve the problem of underinvestment in R&D (Hung, 2017).

The rules of financial markets based on accounting standards consider a positive relationship between R&D investment and higher technology companies as well as in countries where there is greater protection of property rights (Brown et al., 2017). On the opposite side are credit rights and R&D tax credits that contribute to a negative relation to R&D investment in companies with a higher technological level, according to the same authors. Therefore, one can conclude that direct policies related to financial problems and property rights should be more effective than traditional subsidies to promote R&D investments in order to promote economic growth (Brown et al., 2017). (González & Pazó, 2008) they add that subsidies have no effect on R&D expenditure, that is, the subsidies obtained did not influence R&D expenditures of the companies, they would have invested the same, even if they had not obtained subsidies, although in the case of companies where there is no R&D activity, subsidies are an incentive to start these activities.

(Jiang, 2016) found a positive relationship between the future performance of firms and their spending on R&D expenditure, called the effects of externalities on R&D investments. Moreover, companies have higher returns. This means that the market reacts

not only to the companies' R&D investments but also to their peers (Jiang, 2016). The investments carried out by competitors compel the market to be surprised by the positive performance of these companies. There are also positive externalities of R&D investments that can be explained by the expansion of the market due to technological advances (Brown et al., 2017).

The purpose of this work is to analyze the impact of the Paris Agreement has in the companies of the energy sector in Europe after its signature by EU countries, using models of differences in differences. On the one hand, the Agreement could lead to an increase in R&D expenses due to the demand to obtain competitive advantages from their direct competitors, since it is expected that the EU countries will implement laws following objectives of the Agreement. On the other hand, it is likely that there will be a reduction in R&D expenses because R&D investment has a medium-term impact, so that decisions at this level are not immediate, and these expenses have significant weights in the budgets of the companies. Additionally, companies may present reduction in R&D expenses due to uncertainty before a change scenario.

The initial proposition is that the cost of producing electricity through renewables energies is must higher than using fossil energies. So, it is expectable that power companies invest in R&D expenditures as a way of finding ways to reduce the cost of production of renewable energies and/or increase the efficiency of energetic of forms of electric production that already exist. For that, I use a model of difference-in-difference to check if the change of legislation brought a change of behavior, in terms of R&D expenditures, in the companies.

3. Methodology and sample

Due of the existence of new legislation at the macro level in the countries of the European Union, would it have had an impact at the micro level (companies)? What was the reaction of companies in this sector to this impose? In order to answer to this research question, it is necessary to analyze whether, in comparison with other European countries, there were significant differences and considering different periods of time and check if changes the behavior of the companies from the point of view of R&D expenditures.

To explain the behavior of R&D expenditures we use panel data to check if the Paris Agreement signed in October of 2014 have an impact on R&D expenditures after 2014, considering whether the country of the headquarters of the companies belong to a EU28 country. For that reason, a model of differences in differences is used. For a better understanding of the purpose of the study is presented the figure 1 with which the comparison is more perceptible the one that is intended to make.

Headcourters companies	2007-2014	2015-2017
Europe non EU28 Countries		
Europe EU28 Countries		x

Figure 1: Research framework

The model propose is:

$$LogR\&D = \beta 0_i + trend + \beta 1\ logNetIncomeInclExtraBeforeDis\_M_{i,t} + \beta 2\ logCompanyMarketCap2\_M_{i,t} + \beta 3\ Time\ Dummies_t + \beta 4\ Headquarters\ Dummies_i + \beta 5\ Time\ Dummies*Headquarters\ Dummies_{it} + \varepsilon_{i,t} \qquad i = 1,..., N;\ t = 1;\ldots;T$$

The goal of this study is to analyze the impact of the Paris Agreement in the energy sector after the signature by EU28 countries. For that reason, data was collected from the Thompson Reuters database for energy companies from Europe who have the primary code energy and utilities of energy for the period between 2007 and 2017, and, to identify the nationally of the company, this was defined as the nationally of the headquarters of the company. This choose is influence by (Engel, Rothgang, & Eckl, 2016) which according to them, R&D activities are mainly concentrated in the headquarters of the companies. In your model its use the variable trend because the data are long panel data such in (Penela, Morais, & Gregory, 2019). Also, independent variables independent were considered as controls such as Net income and Market capitalization. The control variables Net income and Market capitalization also are collected from the same database. Following (Aschhoff, 2009) its expected the variable Net income have positive signal because the correlation between Net income and R&D expenditures is positive. In the case of the variable Market capitalization, such as in the studies of Jiang and (Wen, Feng, Chang, & Feng, 2018) it's a control variable with an expected positive signal due to be a measure of the size of the companies. As mention by (Aschhoff, 2009) the big companies have the trend to have more investments in R&D. The database was organized by

removing observations of companies that did not have data available for all years of the sample (unbalanced sample). The size of the sample is 429 observations from 22 European countries, 13 of which are from the European Union 28 (see table 2). The remaining countries of Europe were not possible to include in the sample because of the missing values for R&D expenditures of the companies. The table 1 presents the statistical descriptive of the sample where is possible to check the big range in the variable of treatment and in the control variable.

Table 1: Statistical descriptive

Variable	Obs	Mean	Std. Dev.	Min	Max
Research And Development	429	1.71e+09	4.72e+09	1000	3.06e+10
Net Income Incl Extra Before Distributions	429	4.34e+10	1.49e+11	20000	1.36e+12
Company Market Cap	429	4.71e+11	1.07e+12	4357183	4.44e+12
after2014	429	.2890443	.4538478	0	1
EU28	429	.5337995	.4994387	0	1
after2014*EU28	429	.1561772	.3634471	0	1

Table 2: Statistical frequency

Country of Headquarters	Freq.	Percent	Cum.
Austria	16	3.73	3.73
Bosnia and Herzegovina	6	1.40	5.13
Cyprus	2	0.47	5.59
Denmark	8	1.86	7.46
Faroe Islands	4	0.93	8.39
Finland	3	0.70	9.09
France	26	6.06	15.15
Greece	31	7.23	22.38
Ireland; Republic of	1	0.23	22.61
Italy	6	1.40	24.01
Netherlands	20	4.66	28.67
Norway	37	8.62	37.30
Poland	5	1.17	38.46
Republic of Serbia	8	1.86	40.33
Romania	27	6.29	46.62
Russia	100	23.31	69.93
Spain	7	1.63	71.56
Sweden	10	2.33	73.89
Switzerland	4	0.93	74.83
Turkey	37	8.62	83.45

Ukraine	4	0.93	84.38
United Kingdom	67	15.62	100.00
Total	429	100.00	

Two dummies variables were created, one for the period after 2014 that assumes the value 1 and another variable for the host country of the company if it is in Europe, assuming the value 1, otherwise 0. In order to analyze the impact of the Agreement on electricity companies based in the EU countries, a dummy variable was also created, so that when this happens it will assume the value 1 (see figure 2). In another words, its created a control group (companies of non EU28 countries before 2014) to make the contrast with the countries of EU28 on which this framework focused.

Dummy 1 - Time		Dummy 2 - Headcourters	
2007-2014	2015-2017	Europe non EU28 Countries	Europe EU28 Countries
0	1	0	1

Figure 2: Dummy's variables.

Based on the previous words, our research hypotheses is:

H1: The legislation doesn't have impact in the EU28 companies after the Agreement

4. Results

To have an initial idea of the behavior of the impact of the Agreement in this sector, the mean comparison test reveals a statistically significant difference in relation to whether the company is a EU28 country in terms of R&D expenditures. A variable dummy for the years was created. It was defined that 1 is for the years after 2014 (including) and 0 for years before 2014. When analyzing the before and the after the Agreement, the difference between these two periods is not statistically significant, but R&D Expenditures increase after the Paris Agreement (Table 3), this results are point in the same direction of (Aschhoff, 2009) and (Engel et al., 2016).

Table 3: Compare means test (after2014)

ttest ResearchAndDevelopment_M, by(after2014)						
Two-sample t test with equal variances						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
0	305	1.69e+09	2.57e+08	4.48e+09	1.19e+09	2.20e+09
1	124	1.73e+09	4.75e+08	5.29e+09	7.94e+08	2.67e+09
combined	429	1.71e+09	2.28e+08	4.72e+09	1.26e+09	2.15e+09
diff		-4.02e+07	5.04e+08		-1.03e+09	9.50e+08
diff = mean(0) - mean(1)					t = -0.0797	
Ho: diff = 0				degrees of freedom =	427	
Ha: diff < 0			Ha: diff != 0		Ha: diff > 0	
Pr(T < t) = 0.4682			Pr(|T| > |t|) = 0.9365		Pr(T > t) = 0.5318	

The same procedure was done for the variable EU28. Value 1 was defined for countries that belong to the European Union and 0 for European countries outside the European Union. Similar results were obtained in what concerns of the signal of this difference, i.e., the headquarters of companies in EU countries of the energy sector have bigger R&D expenditures, but this difference is statistically significant (table 4), these results are interesting because they go against the perception that we have without having been made a quantitative analysis, but this results are a preliminary results because we want analyses relationship between EU28 companies and after 2014.

Table 4: Compare means test (EU28)

ttest ResearchAndDevelopment_M, by(EU28)						
Two-sample t test with equal variances						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
0	200	3.24e+09	4.61e+08	6.52e+09	2.33e+09	4.14e+09
1	229	3.70e+08	6.57e+07	9.95e+08	2.40e+08	4.99e+08
combined	429	1.71e+09	2.28e+08	4.72e+09	1.26e+09	2.15e+09
diff		2.87e+09	4.36e+08		2.01e+09	3.72e+09
diff = mean(0) - mean(1)					t = 6.5684	
Ho: diff = 0				degrees of freedom =	427	
Ha: diff < 0			Ha: diff != 0		Ha: diff > 0	
Pr(T < t) = 1.0000			Pr(|T| > |t|) = 0.0000		Pr(T > t) = 0.0000	

In view of the results obtained it can be inferred that based on the comparison of means it is not clear what impact the Paris Agreement had in terms of R&D expenditures, but it

gives an initial idea of what the expected signal will be when the results are obtained through the DiD model. Due to the data obtained per company and over 10 years we analyze the behavior of R&D expenses using panel data. For that reason, one variable of interaction between the period after the Agreement and the EU28 countries (after2014*EU28) was created, in order to measure the effect of R&D expenditures on countries of EU after the Agreement, as mention before.

Table 3 show us three regressions which explain the impact that the Paris Agreement had in the R&D expenditures. The first model, Ordinary Least Square (OLS), show us a regression where R&D expenditures are explained by the variable of interaction EU28*after2014 at the significance level of 5%. The remaining variables (after and EU28) are not significant at the 10% level, with an opposite sign between them. Control variables (Net income and market capitalization) are statistically significant at 1%.

The analysis of fixed effect (FE) reveals us negatives values in all cases, being significant at 5% in the case after 2014 and significant at 10% in the case of the variable of interaction between the time and the headcounters countries of the companies. Another result that can be purged from Table 5 is that there is a positive relationship between R&D expenditures and net income of companies, which is statistically significant in all three models, in line with the results of (Jiang, 2016). The market capitalization value also shows a positive relation with R&D expenditures.

In the case of the model with random effects (RE), the variables after the Paris Agreement and the variable after2014EU28 present negative values with a significance level of 5% and although not statistically significant, the EU28 variable also has a negative sign.

Another variable that helps to explain the behavior of R&D expenses is the inclusion of trend, which in this case is positive in all cases presented. It should be noted that it is not only statistically significant in the case of FE. In other words, with this sample, it can be inferred that, after the Agreement, R&D expenditures decreased, R&D expenditures in EU countries also decreased, when differences between them and the rest of Europe were analyzed. Companies based in EU countries after 2014 have also cut their R&D expenditures.

Table 5: Variable dependent log Research and Development

	(1) OLS	(2) FE	(3) RE
VARIABLES	logResearchAndDevelopment_M	logResearchAndDevelopment_M	logResearchAndDevelopment_M
trend	7.63e-05*	0.0246	0.000153*
	(4.14e-05)	(0.0352)	(8.19e-05)
after2014	-0.285	-0.466*	-0.349**
	(0.249)	(0.259)	(0.166)
EU28	0.267		-0.0439
	(0.222)		(0.397)
after2014EU28	-0.879**	-0.427	-0.466**
	(0.381)	(0.317)	(0.234)
logNetIncomeInclExtraBeforeDis_M	0.589***	0.185*	0.299***
	(0.0506)	(0.110)	(0.0539)
logCompanyMarketCap2_M	0.277***	1.908	0.512***
	(0.0508)	(3.734)	(0.0745)
Constant	-0.848	-143.6	-0.493
	(0.696)	(164.8)	(1.394)
Observations	429	429	429
R-squared	0.738	0.089	
Number of company_id		89	89

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Discussion

The purpose of this work is analyses the behavior of R&D expenditures in companies of energy sector with the headquarters in Europe. Looking to see if there are different between companies based in EU countries and outside the EU. To do this, having as a base group the companies outside the EU in the period up to 2014 sought to see if there were differences compared to EU companies after 2014.

The contributions of this work were that the results obtained in relation to R & D expenses were contrary to our initial expectation. All three models point in the same direction, the Paris Agreement after 2014 brought a decrease of R&D expenditures in all companies in Europe face to antecedent period. This results point in a different direction from (Franzen et al., 2007) (Lee & Lee, 2013) studies which state that R&D expenditures has been increasing over time due to maintain the competitively of the companies. Being the

energy sector have an important role in the economy, geopolitical, technological and environmental it is important to find out the reasons for the decrease in R&D spending in the European countries, especially in the EU countries since the 2014 Agreement focuses on them. As the sample collected is from listed companies, following (Makri, Hitt, & Lane, 2010) (Majumdar, Moussawi, & Yaylacicegi, 2014) it's preferable to buy this technology already developed by start-ups and thus accelerate the process of insertion of this new technology in companies. That way, this decrease could be explained be the fact that companies may have redirected their investment to purchase assets such as solar panels or wind turbines in order to comply with the Paris Agreement, thus divesting them of developing new technologies or improving their energy efficiency. Another aspect that could justify these results it's the possibilities of the national or the EU give subsidies to the companies for they do research and that money being classified in another accounting item. Another hypothesis is the R&D expenses are associated with very high fixed costs and therefore the changes in the behavior of these agents are not immediate. Other factors that may explain this reduction in R&D expenditure are the fact that R&D investment has a medium-term impact, so that decisions at this level are not immediate, and these expenses have significant weights in the budgets of the companies. Additionally, companies may present reduction in R&D expenses due to uncertainty before a change scenario.

6. Conclusions, recommendations and limitations

Through the differences model in panel data, a statistically significant negative relationship was found between R&D expenditures and the signing of the Paris Agreement in 2014. In the case of the variable after2014 the relation is negative in the 3 cases studied, OLS, FE and RE. In case of variable EU28 relationship with R&D expenditures is not clear and not statistically significant. The variable of interaction between the period after the Agreement and the headcounters of companies in the EU28 is negative, but in the case of FE isn't statistically significant. In a generalized way, the obtained results, contrary to the initial expectation, the Paris Agreement, the analysis through panel data, did not bring an increase in R&D expenditures in EU countries. The main contribution of the work was that there was a decrease in R&D expenditure by

companies based in countries of the European Union after the Paris Agreement. For that reason, it will be necessary to create more incentives for companies to increase R&D expenditure faster and faster in order to achieve the targets of the Paris Agreement and that way obtain a sustainable economy, which should be possible through technology and energy consumption with a minor environmental impact and thus help to achieve the objectives of the triple bottom line approach.

One possible explanation for these results is the fact that no distinction has been made in the type of company linked to the electricity sector and may exert different behaviors in renewable energy companies compared to non-renewable companies in terms of R&D expenditures, so it suggests carrying out such a study.

Another possible study is check if the Agreement have impact in other countries such US or China. Another suggestion of work to be undertaken is to analyze only the EU28 renewable energy companies and to check if there was any increase in R&D expenditure after the Paris Agreement. Due to the objectives of the Paris Agreement, it will also be interesting to analyze the sector of oil companies which will have the greatest direct effect not only in terms of R&D but also in terms of performance. Another aspect to have in consideration it is the fact of the study intends to analyze the companies in the electricity sector in Europe and that data on R&D spending is not available in all companies, for that reason the study is limited to the available data and can make a generalization of the same for this type of expenditures. Other explanatory variables such as Net Income, EBITDA, Revenues and the number of employees in the models were tested (Jiang, 2016) but due to problems of heterogeneity and multicollinearity were taken from the presented models.

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