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An Analysis of the Impact of the 2030 Agreement on R&D Intensity in the Energy Sector[1]

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ABSTRACT

European Union countries 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 that has opened new avenues of research. Because the 2030 Agreement imposed targets to be achieved by 2030, energy companies could increase their R&D expenditures as they search for increased efficiency through a reduction of carbon dioxide emissions and stronger base in renewable sources that promotes innovation. In addition, the risks that arise from climate change can compromise the successful achievement of the targets, such as 27% renewable energy consumption, reduction in emissions of carbon dioxide by at least 40% and to improve energy efficiency. In this study, I conduct an evaluation of the behavior of R&D intensity in this sector. It analyze the behavior of companies related to the electricity sector in two different moments, before and after the 2030 Agreement, by using panel data and comparing the listed companies with headquarters in European Union countries with companies headquartered elsewhere in Europe. The results show that the 2030 Agreement had no effect on R&D intensity in companies in the electricity sector in the countries of the European Union.

Keywords: R&D Intensity, Electricity Sector, 2030 Agreement, Panel Data
JEL Classifications: K32; O13; O32; Q48; Q55

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1. INTRODUCTION

The 2030 Climate and Energy Framework Agreement was signed in 2014 by European Union (EU) countries. The Agreement has three main objectives to achieve by 2030: to reduce greenhouse gas emissions by at least 40% from the levels of 1990; to consume at least 27% of renewable energy; and to improve energy efficiency through possible amendments to the energy efficiency directive (European Council, 2014). To achieve these goals, new technologies and/or improvement in energetic efficiency of existing technologies must be developed. In both cases, implementation will only be possible, in all likelihood, through an increase in research and development (R&D) expenditures. For example, an excerpt of a statement made by the largest Portuguese operator, EDP (2018, p. 35) states the following: "The path of decarbonization implicates a deep change to the economic model based on fossil fuels, a strong bet in energy efficiency, electrification based in renewables and the promotion of innovation."

According to Kahouli (2018), "the energy sector has an important role in the new challenges both economic, geopolitical, technological and environmental". This is reinforced by the 2015 report by the Intergovernmental Panel on Climate Change (IPCC) which mentions that key economic sectors such as energy, water, transport, human health, human security and poverty will experience effects from climate change. How to lead with innovation and the climate change is one of the most prominent topics regarding sustainability

(Calabrese et al., 2018) and also terms such carbon and renewable energy (Estevão, 2021).

As Franzen et al. (2007) and Lee and Lee (2013) show, the expense of R&D has been increasing over the last 20 years, because companies want to be competitive and so need to modernize and innovate in order to gain competitive advantages against the opponents. One-way companies can obtain competitive advantages is through the development of new technologies or by increasing the efficiency of existing technologies. Therefore, companies need to invest more in R&D (Peteraf, 1993). This is in line with the research that shows that a positive relationship exists for companies in terms of R&D and the investment made in the previous period (Su and Moaniba, 2020).

According to Lin and Chen (2019), the innovation of renewable energy technologies is positively associated with R&D expenditures and economic growth. In addition, sustainable economies depend on the reduction of greenhouse gas emissions that should only be possible through technology and energy consumption with a minor environmental impact (Fernández Fernández et al., 2018).

Nowadays, as the world population continues to grow, a significant part of the developed world is placing a strong emphasis on future generations, especially in developing countries. In these countries, the energy sector has an important role in the new economic, geopolitical, technological, and environmental challenges (Kahouli, 2018). According to Toledano et al. (2020), the utility sector was responsible for 41% of global emissions in 2017, and of those emissions electricity and heat generation were the worst. For that reason, the alignment of electricity utilities with the United Nation's Sustainable Development Goals (SDGs), mainly through SDG 7 (renewable energies) and SDG 13 (climate changes), is important. Electricity companies are subject to risks arising from climate change. According to Wei et al. (2016), these risks can be operational (risks of extreme weather events that can occur may compromise facilities, manufacturing, supplies, and the workforce), input risks due to a reduction of natural resources, market risks through a change in the demand for electricity services or products; financial risks due to possible financial losses, reputational risks because the various stakeholders can be disappointed given their expectations about the companies, and last but not least, regulatory risk due to the increasingly stringent climate policies and the potential result of rising prices of high carbon sources of energy.

The purpose of this study is to analyze the impact that the 2030 Agreement had on the companies in the energy and utilities sectors in Europe. The Agreement takes effect in 2015, with the window of analysis being pre-signature (up to the signing in 2014) and 2015 onwards is period of the impact of the Agreement, which corresponds to the implementation period. According to the United Nations, (2015), line 5 in article 10 of the Agreement states its mission: "Accelerating, encouraging and enabling innovation is critical for an effective, long-term response to climate change and promoting economic growth and sustainable development."

Therefore, the Agreement could lead to an increase in R&D expenses due to the need for competitive advantages over their direct competitors. The Agreement could affect the intensity of R&D through its imposition of limits on carbon dioxide emissions and its expansion renewable energy consumption, with more advantages than disadvantages (Maradin, 2021). According to Wei et al. (2016), there should be 3.9 trillion dollars invested in renewable energy by 2030. This level might enable companies to achieve the objectives proposed by the Agreement.

However, the Agreement could reduce R&D expenses because this investment has a medium-term impact, and these expenses have significant weights in the budgets of the companies. Additionally, companies may reduce R&D expenses due to uncertainty before a change scenario. According to Mudambi and Swift (2011), the external turbulence from the change in regulation can create reactions in the levels of R&D expenditures, as companies wait for a clearer set of rules.

Based on these conjectures, two research question (RQ) emerge that this study aims to address:
RQ1: Is there a change in the R&D intensity of energy companies after the 2030 Agreement?
RQ2: Is there asymmetric change in the R&D intensity of energy companies between EU28 and non-EU28 energy companies after the 2030 Agreement?

Subsequently, this study tests the hypothesis that companies in the EU28 have different R&D intensities than the companies in non-EU28 countries. We also test the hypothesis of a change in the R&D intensity after the Agreement in the energy companies in non-EU28 countries as they did not sign the 2030 Agreement. To answer these research questions, we use a panel data method.

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

2. LITERATURE REVIEW

Greenhouse gas emissions have followed the trend of increasing energy consumption. Yet, energy efficiency improvements through technological development and innovations introduced in the energy sector companies could invert that trend (Costa-Campi et al., 2015). So, R&D expenses on low-carbon technology could facilitate the reduction of CO_2 emissions and consequently transform into energy savings (Gu and Wang, 2018). Brandão and Ehrl, (2019, p. 432) reinforce this idea and claim that "R&D investments contribute to a reduction of CO_2 emissions through the development and implementation of environmentally friendly technologies". In the same way, Alam et al. (2019) demonstrate that in countries such as the G-6, the impact of R&D investment is negative for energy consumption and also for the intensities of carbon emissions.

Another way of reducing CO_2 emissions is by increasing the use of renewable resources (Sim, 2018). The governments' policy aims can influence the speed of development of these resources (Kim et al., 2014). However, in countries where the petroleum refining sector has a large presence, governmental policies for R&D investment in renewable energy have a negative relationship with government budgets for energy R&D. Nevertheless, there is a positive relationship between fossil fuels and R&D investment that is reflected in the search for new forms of extraction of fossil fuels (Sun and Kim, 2017).

Based on the IEA 2017 report, just 18% of world primary energy supply was non fossil in 2015. The growth in the demand for fossil fuels around the world in this century was accompanied by rising CO_2 emissions of which fossil fuels were the main culprit (Zhao and Luo, 2017).

There are several factors that can condition R&D expenditures in a company, such as its strategy, financing, budget (Heidenberger et al., 2003), profitability (Lin and Wang, 2016), market growth (Brown et al., 2016), its previous investment in R&D (Alam et al., 2019), location (Engel et al. (2016), institutional environment (Alam et al., 2019), and pressure for sustainable economies. According to Kahouli, (2018), an energy sector with greater economic sustainability is the most intelligent approach to future global efforts to save energy.

One of the main factors that influences R&D is the location of companies' head offices because companies normally carry out their R&D activities at their headquarters (Engel et al., 2016). Further, this dependence also exists because of the previous investment that was made in R&D (Alam et al., 2019), since R&D are medium term investments with uncertain returns.

Before carrying out R&D expenditures, a company must first secure funding. For Coad and Rao, (2010), the financing of R&D expenditures has several difficulties: first, the return on the funds invested in R&D is unknown both in terms of profitability and of the payout period. Second, 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 its R&D project (Guiso, 1998). Information asymmetries (of the "adverse selection" type) 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 (Mudambi and Swift, 2014).

According to Bhagat and Welch, (1995), managers in the presence of low operational cash flow in companies could use the cash flow available to invest in R&D, with the expectation of future returns on the operational cash flows and avoiding the costs of external capital. However, the investment into innovative outputs is less efficient when the free cash flow is positive (Podolski, 2016). On the other hand, there are studies that point to the fact that companies with larger cash flows have the propensity to invest more in R&D (Alam et al., 2019) to avoid the costs of external capital markets (Bhagat and Welch, 1995).

In order to have a high operational cash flow, small innovation companies traditionally have higher capital costs for external financing due to asymmetric information. But those costs can be mitigated by the existence of venture capital (Hall and Lerner, 2009). Whether capital costs are high for large R&D companies is not clear. However, large companies typically prefer using internal capital for R&D investment to guarantee the financing and to reduce the adverse selection problem. Following Alam et al. (2019), the cash flows usually have a positive relation with R&D. The rationality behind this relation is the fact that companies that have more cash flow have a greater propensity to spend more money on R&D expenditures. Therefore, a positive relation should exist between cash flow and R&D intensity.

On the other hand, bank loans are the most traditional form of financing the R&D investment. According to Ogawa (2007), in cases of firms which already have outstanding debt, new issues can bring pressure and a negative impact on investment due to paying a finance premium that discourages new investments; outstanding debt and new debt increase the probability of bankruptcy, or at least financial distress, which managers tend to avoid. Laborda et al. (2020) add that companies need to control cash flows to avoid financial constraints in order to increase leverage and optimize debt costs. Moreover, countries with higher levels of common trust have more R&D expenditure to promote innovation, and this trust could diminish information asymmetries, inferior monitoring, and transaction costs that increases investors' risk-taking (Meng et al., 2020). Consequently, the cost of debt reduces and allows companies to access more external financing. But in the face of economic and political instability, the capital costs can increase considerably (Xu, 2020). Therefore, a negative relation should exist between the debt ratio and R&D intensity.

The financial constraints on firms' R&D intensity are seen as a discontinuity or a suspension of R&D projects (Li, 2011). These actions can affect the R&D intensity of companies that leads them to be the target of more acquisition proposals and, as a result, creates greater risk for them as well as being financially constrained (Lin and Wang, 2016). This discontinuity or suspension of projects can mean a reduction in the value of the company given the probability that the company will be unable to finish its R&D project before its competitors. 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 (Morbey, 1989; Lee, 2018). However, R&D investment is related to sales and employment. A different view was presented by Klette and Griliches (2000) who claim that the growth of the company depends on R&D and innovation spending. On the other hand, Kumar and Li (2016) argue that technologically mature industries make capital investments for the purpose of growing assets that presents a negative relation between the investment in capital and short-term yields. 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 and Swift, 2014). Companies in industries that focus on innovation proactively use capital investment to facilitate the generation of new growth options by building innovative capacity (Pike et al., 2005). Lee and Lee (2013) show that the number of energy patents, mainly in ocean and geothermal technologies, has increased in the last 20 years. In addition, investment in innovation capacity increases the expected revenue, allowing the company to make sales based on the quality of the innovations, conditioned to its creation and development (Mudambi and Swift, 2014); Coombs (1996) finds that intangible assets are one of the main drivers of innovation and organizational value. If a company has a certain revenue stream, it will put some of it into R&D in the next period (Coad and Rao, 2010).

Jiang (2016) finds a positive relationship between the future performance of firms and their spending on R&D, which Jiang calls the effects of externalities on R&D investments. Moreover, companies have higher returns. Another aspect to bear in mind is 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., 2016).

In addition to the above, other factors also affect the R&D intensity such as the strategy of a company and its dimension. Larger firms have a tendency to be more differentiated, more technologically complex, and more cognizant of technological opportunities (Hagedoorn and Schakenraad, 1994). Looking at tangible assets, the size of the companies, usually measured by a proxy of total assets, has a positive relation with R&D investments (Aschhoff, 2009). Szücs (2020) finds that companies with higher R&D intensity have a propensity to increase their R&D when they participate in subsidized projects. Therefore, a positive relation is expected between total assets and R&D intensity.

Innovation and productivity growth are due to investment in R&D, but financing difficulties make this investment smaller than the optimal social level (González and Pazó, 2008), particularly for companies with higher technological intensity (Brown et al., 2016). 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, 2016).

The rules of financial markets that improve 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., 2016). On the opposite side are credit rights and R&D tax credits that contribute to a negative relation with 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 that facilitate economic growth (Brown et al., 2016). González and 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 because they would have invested the same without the subsidies. However, in the case of companies where there is no R&D activity, subsidies are an incentive to start these activities. In some industries, the environmental regulations and R&D subsidies are enhancers of green innovation efficiency (Yi et al., 2020).

Another aspect to pay attention to is that energy R&D influences the supply of energy; but energy consumption, of course, determines the demand for energy which in turn affects the growth of GDP (gross domestic product) in the economy (Wong et al., 2013). Kocsis and Kiss (2014) support the positive relation between GDP and high levels of R&D expenditures through renewable energy consumption. The GDP and the cumulative knowledge induced by public R&D expenditures allows "each billion EUR of GDP leading to an additional knowledge of 3.1 mil EUR" (Bointner, 2014). A stronger incentive to R&D investment is the growth in GDP (Wang, 2010).

The R&D in companies can be influenced by intrinsic factors such as sales, cash flows, and assets; and extrinsic factors such as political stability, government effectiveness, regulatory quality, and control of corruption (Krammer, 2015). Alam et al. (2019) is a pioneer study that, for the first time, focused on emerging markets with a combination of several extrinsic factors. Other studies had focused only on one extrinsic determinant to explain the R&D investment. This study intends to apply the same idea of intrinsic and extrinsic factors can influence the energy market in European companies.

The innovation activities in companies can be influenced by institutions through laws, regulations, and policies (Wang et al., 2015). The R&D investment may be encouraged by effective institutions through the reduction of the agency problem with investors (Choi et al., 2014). The knowledge accumulation and its spillover can expand in a country with stronger institutional settings and help short-term R&D investment (Yi et al., 2013).

The political situation of any country has an important influence on corporate investment. Political stability is a means to achieve a favorable investment environment, as stability guarantees continuation of economic policies and reduction of future uncertainty. R&D investment is also influenced by political conditions (Karadayi and Ekinci, 2019). R&D investment is medium to long term and risky in nature. Therefore, the presence of instability in the political situation will affect R&D more than other forms of company investments (Masino, 2015). The same author shows that due to the volatility and the uncertainty in the economy, companies tend to reduce the level of R&D investment. This uncertainty makes the value of the option to wait before making investments increase (Atanassov et al., 2016). Political decisions to stimulate investment in the short term influence government policy and condition future political and regulatory decisions in the long term (Julio and Yook, 2012).

Pearce et al. (2011) state that government effectiveness can influence corporate performance based on the effects of managerial assumptions and actions which allows for a reduction in agency costs. In the presence of lower agency costs, the efficiency of the investment is likely to increase. Entrepreneurial activities can be promoted through fiscal policies by governments as a way for companies to invest more in R&D (Jiao et al., 2015). Effective government can inspire and incentivize private and public companies to be involved in R&D investment and stimulate entrepreneurial activities. In emerging markets, the role of government has a greater contribution to improving innovation performance in companies by offering grants for innovation activities (Szczygielski et al., 2017). As pointed out by Hong et al. (2015), the role of the government gains greater prominence in these markets.

Hillier et al. (2011) was one of the first studies to look at R&D through the prism of external factors and how these can affect R&D. They found that the relationship between R&D and law enforcement had little sensitivity to changes. The quality of the rule of law (law enforcement) is higher in the countries with less asymmetric information and in turn leads to lower capital costs. Pindado et al. (2015) reinforce the idea that strong legal systems, where for example the question of protection of minority shareholders or protection of creditors' rights is ensured, provides investors with a greater propensity to invest in R&D. Law enforcement mitigates opaque information. Seitz and Watzinger (2017) find a positive relationship between R&D intensity and contract enforcement. The R&D intensity in an industry increases with the quality of the judicial system. With a better judicial system, companies have more confidence to invest in R&D.

According to Blind et al. (2017), the market environment can influence the relation between innovations and regulations; they find evidence that in markets with low uncertainty, regulation has a positive impact; but in the case of markets with high uncertainty, regulation has a negative impact. Karadayi and Ekinci, (2019) add that good regulatory quality increases R&D efficiency. However, if the companies are in the presence of a good quality regulatory environment, investors are willing to invest and attract foreign investment; but the same is valid for foreign investment in weak government regulations were these investors are reluctant to put their money into R&D projects (Kirkpatrick et al., 2006). In the case of Mahendra et al. (2015), they find evidence that innovation is positively influence by good regulatory quality and access to finance. The energy sector is a highly regulated market by nature that is going through a phase of deregulation. These factors have caused R&D to decrease rather than increase (U-inverted) (Marino et al., 2019).

3. METHOD AND SAMPLE DATA

3.1. Method

The goal of this study is identifying how the 2030 Agreement has affected the R&D intensity of the energy sector of listed companies with headquarters in EU28 countries. For that reason, data were collected from the Thompson Reuters database for the period between 2010 and 2019. Therefore, its use the panel data methodology. Following Engel et al. (2016), R&D activities are mainly concentrated in the headquarters of the companies; for that reason, the nationality of a company was identified according to its headquarters.

To control the level of R&D intensity, data were also collected from Thompson Reuters on the total assets, cash flows, and debt ratio of these companies.

Furthermore, its use several additional control variables. GDP per capita controls for economic development and economic conditions each year. To control for the economic development of the country and indicators of perception of governance such as political instability and rule of law are retrieved from the Worldwide Governance Indicators (WGI) of the World Bank.

Table 1 presents the variables, their definitions, and the studies they come from.

Therefore, to answer the RQ 1 and 2, we propose the following three equations:

1. *ln R&D intensity = ln R&Dintensity it-1 + ln Total Assets it + Cash – Flow it + debt ratio it + GDP per capita it + Political Stability it + Rule of Law ti +* $\varepsilon it + \mu it$
2. *ln R&D intensity = ln R&Dintensity it-1 + after2014*EU28 + ln Total Assets it + Cash – Flow it + debt ratio it + GDP per capita it + Political Stability it + Rule of Law it +* $\varepsilon it + \mu it$

The results presented consider two models, an OLS (Ordinary Last Squares) and a panel-data models. The latter is a FE (Fixed Effects), after testing against a RE (Random Effects) model, that controls for the firm's characteristics. It is common practice to present just two models, the OLS model and one of the two panel-data models (FE or RE) based on Hausman's test, which favoured the former. In this case the p-value of the Hausman test is 0.0000 that indicates the FE model better explains R&D intensity than the RE model. Therefore, its present the OLS and FE models to ensure the consistency of results.

3.2. Data

The sample consists of 414 listed companies in the energy sector in Europe. Because the disclosure of this type of expenditure is not mandatory, there are companies in the database that do not release this information, which is the reason for the existence of missing values. The sample was organized by removing observations of companies that did not have data available for R&D expenditures (unbalanced sample), and the same procedure was used for the control variables. After removing the missing values and unrealistic figures (such as negative values of R&D expenditure) from the sample, 95 firms remained in the sample and represent 557 firm-years. Considering this number, we analyzed the weight that these companies had in the sector, and they represented about 69.96% of the revenues in the energy sector.

Tables 2-4 present the descriptive statistics, the results of the VIF test, and the matrix of correlations between the variables. The main variable under study (R&D intensity) presents an average value of about 4%, which can be considered within the normal values for

Table 1: List of variables and definitions

Variable	Description	Author (s)
LnRDintensity	Represents the natural logarithm of R&D intensity in period t.	Alam et al. (2019); Chen et al. (2013) Makri et al. (2010); Su and Moaniba (2020)
L.RDIntensity	Represents the R&D intensity in period t-1.	Alam et al. (2019); Inglesi-Lotz (2017)
after2014	A binary variable equal to one from 2015 onward, and zero otherwise.	Sapio and Spanolo (2016)
EU28	A binary variable equal to one if the headquarters of a company is in EU28, and zero otherwise.	Spencer et al. (2017)
LnTotalAssets	Represent the natural logarithm of total assets.	Alam et al. (2019) Meng et al. (2020) Wu et al. (2019)
Cash Flow	The sum of net income after taxes minus preferred dividends and general partner distributions plus depreciation and amortization of intangibles for the fiscal period.	Bhagat and Welch (1995) Podolski (2016) Xu (2020)
Debt ratio	The ratio between total debt and total assets of a company in period t.	Alam et al. (2019); Meng et al. (2020) Xu (2020)
GDPpc	Represents the GDP per capita of the countries in period t.	Alam et al. (2019); Kahouli (2018) Marino et al. (2019);
Political Stability	Measures the perceptions of the likelihood of political instability and/or politically motivated violence like terrorism. Source: World Bank (WGI).	Julio and Yook (2012) Karadayi and Ekinci (2019) Masino (2015)
Rule of law	Reflects the perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts as well as the likelihood of crime and violence. Source: World Bank (WGI).	Hiller et al. (2011) Pindado et al. (2015) Seitz and Watzinger (2017)

Table 2: Descriptive statistics

Variable	Obs	Mean	SD	Min	Max
RD intensity	557	0.042735	0.112585	0.000029	1.166203
After 2014	557	0.585278	0.493116	0	1
EU 28	557	0.590664	0.492153	0	1
After 2014*EU28	557	0. 357271	0.479626	0	1
Total assets	557	2.12e+10	5.48e+10	1476855	3.150e+11
Cash flow	557	2.10e+09	5.67e+09	-2.30e+09	4.01e+10
Debt ratio	557	0.212443	0.218758	0	1.259726
Gdp pc	557	41963.25	15714.50	11237.07	86781.39
Political stability	557	0.236839	0.804639	-2.020833	1.418336
Rule of law	557	1.152871	1.015182	-0.818469	2.096355

Table 3: Results of VIF test

Variable	VIF	1/VIF
GDP_pc	5.04	0.198583
Political stability	4.60	0.217557
Ln total assets	2.12	0.471283
Rule of law	1.96	0.509413
Cash flow	1.68	0.596515
l.ln RD intensity	1.52	0.656557
Debt ratio	1.13	0.888655
Mean VIF	2.58	

this type of ratio. It is worth noting the wide range between the minimum and maximum. The other variable that deserves to be highlighted is the debt ratio with a wide range of values.

The Pearson correlation matrix shows the results of analyzing the relationship between R&D intensity and the other variables. R&D intensity presents a negative correlation with the period after the Agreement (after 2014), and a positive correlation with EU28 companies. The correlations that show statistically significant values are evidence that there may be a relationship between the variables. In case there are relationships between the variables, it may lead to multicollinearity problems. In order to avoid this kind of problem, it was performed a VIF test that had results lower than 10 (Table 3) as suggested by (Meng et al., 2017). In view of the above, there are guarantees that the relationships are stable and can be analyzed through linear regression in panel data given the stability of the correlations.

The sample in terms of geographical distribution shows 19 European countries of which 14 are from the EU28 (the other countries have no observations available) and 5 are from countries outside of the EU28 (Norway, Republic of Serbia, Russia, Switzerland, and Ukraine) (Table 5). 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.

Table 6 presents the panel unit root tests based on Augmented Dickey-Fuller (ADF). The ADF was chosen as it permits unbalanced panel data. The null hypothesis of a Fisher-type test is that panels hold unit roots (i.e., the variables are non-stationary). Based on Alam et al. (2019), the results show that R&D intensity, lag R&D intensity, Total Assets, Cash Flows, Political Stability, and Rule of Law are stationary; while after first-order differencing, *GDP* per capita and debt ratio stay stationary. The results confirm that the variables in our model are stationary which means that the regressions are not spurious.

4. RESULTS

Table 7 shows the results of the regressions that use the data with no restrictions to identify the determinants of R&D intensity

Table 4: Pearson correlation matrix

Variable	1	2	3	4	5	6	7	8	9	10
RD intensity	1									
after2014	−0.0699*	1								
EU28	0.120***	0.0511	1							
after2014*EU28	0.0183	0.662***	0.575***	1						
Total assets	−0.103***	0.0187	−0.0992***	−0.0470	1					
Cash flow	−0.100***	−0.0316	−0.163***	−0.111***	0.933***	1				
Debt ratio	−0.133***	0.0663*	−0.147***	−0.0294	−0.00300	−0.0314	1			
GDP pc	0.113***	0.0836**	0.239***	0.210***	−0.101***	−0.138***	0.172***			
Political stability	0.117***	−0.0612	0.347***	0.149***	−0.144***	−0.176***	0.112***	0.881***	1	
Rule of law	0.167***	0.0005	0.385***	0.202***	−0.221***	−0.282***	0.0744*	0.646***	0.649***	1

This table presents the Pearson correlations of the variables used in the study. P<0.1*, P<0.05**, P<0.01***

Table 5: Statistical frequency of observations by headquarters

Country of headquarters	Freq.	Percent	Cum.
Austria	18	3.230	3.230
Cyprus	4	0.720	3.950
Denmark	9	1.620	5.570
Finland	3	0.540	6.100
France	42	7.540	13.64
Germany	25	4.490	18.13
Greece	9	1.620	19.75
Ireland, Republic	25	4.490	24.24
Norway	82	14.72	38.96
Poland	4	0.720	39.68
Republic of Serbia	9	1.620	41.29
Romania	27	4.850	46.14
Russia	94	16.88	63.02
Spain	14	2.510	65.53
Sweden	5	0.900	66.43
Switzerland	4	0.720	67.15
Turkey	35	6.280	73.43
Ukraine	4	0.720	74.15
United Kingdom	144	25.85	100
Total	557	100	

Table 6: Panel unit root test

	Level	First difference
RD intensity	559.5046***	
Ln RD intensity	257.4701***	
Ln Total Assets	289.4041***	
Cash Flow	382.9208***	
Debt ratio	157.7169	195.8894***
GDP per capita	157.1252	188.5008**
Political Stability	462.0521***	
Rule of Law	310.0322***	

All panel unit root tests were performed without intercept, drift, and trend for all variables. Level of significant: *<0.10, **<0.05, ***<0.01.

Table 7: Ln R&D intensity, full sample

Variables	(1)	(2)
	OLS	FE
L.ln RD intensity	0.722***	0.120
	(0.053)	(0.084)
lnTotal Assets	−0.075**	−0.565***
	(0.030)	(0.169)
Cash Flow	0**	−0
	(0)	(0)
Debt ratio	−0.490*	−1.069**
	(0.252)	(0.513)
GDP_pc	0.000**	0.000
	(0.000)	(0.000)
Political Stability	−0.127	−0.505*
	(0.153)	(0.274)
Rule of Law	0.089*	0.817
	(0.050)	(0.909)
Timme Dummies	Yes	Yes
Constant	−0.360	6.139
	(0.686)	(4.142)
Observations	557	557
R-squared	0.676	0.248
Number of company_id		95

Robust t-statistics are in parentheses. P<0.1*, P<0.05**, P<0.01***. In columns 2 and 3, the outcome variable is logarithmic function of R&D intensity. LlnRDintensity is the logarithmic function of R&D intensity in period t-1. LnTotal Assets represent the logarithmic function of the sum of total assets; long-term receivables; investment in unconsolidated subsidiaries; other investments; and net property, plant, and equipment and other assets. Cash Flow is the sum of net income after taxes minus preferred dividends and general partner distributions plus depreciation and amortization of intangibles for the fiscal period t. Debt ratio is the ratio between total debt and total assets of companies in period t. GDPpc represents the GDP per capita of the countries in period t. Political Stability measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism. Rule of law reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

in the energy sector. As in Alam et al. (2019), R&D intensity is positively related to that in the previous period for the OLS model. According to Wooldridge, (2013) when the value of the coefficient is higher than 0.1, an adjustment should be made for the interpretation to obtain the exact value. This model presents a persistence rate of 105% [exp (0.722) −1] that indicates firms follow a stable R&D policy in the energy sector. Nerveless, in the FE models this relation is not significant.

The total assets show a negative impact on R&D intensity in both models. In the OLS model, when the total assets increase by 1%, the R&D intensity decreases by 7.5%, ceteris paribus. For the FE models, the effect is larger at 43% [exp (−0.565) −1], ceteris paribus. These results go against the hypothesis of a positive relation between total assets and R&D intensity, which can be interpreted as less willingness by listed energy companies to take on R&D risks.

In the case of cash flows, we find a positive impact on R&D intensity in one model. The OLS model shows a positive impact that is significant at the 5% level. In both cases (OLS and FE) the value is very close to zero. Therefore, the results of OLS model do support the hypothesis of a positive relation between cash flow and R&D intensity. This support could mean that energy companies with bigger cash flow have the propensity to invest more in R&D (Alam et al., 2019) and to avoid the costs of external capital markets (Bhagat and Welch, 1995).

The regressions also present a statistically significant and negative relation with the debt ratio in both models. This relation can perhaps be explained by the fact that these companies are the largest in this sector, so typically they have lower levels of debt due to the confidence they convey to funders (Meng et al., 2020). For the OLS model, a 1% increase in the debt ratio leads to a 38% increase in the R&D intensity, ceteris paribus. Meanwhile, the values presented in the models are statistically significant at the 10% level for OLS model and at the 5% level for the FE model. Therefore, we predict that a negative relation will exist between the debt ratio and R&D intensity, following the expectations of the literature. Ogawa (2007) states that for the firms which already have outstanding debt, new issues can bring pressure and a negative impact on investment due to a finance premium that increases the probability of bankruptcy and discourages new investments.

The GDP per capita of the country in which the company is headquartered is also positively related with R&D intensity, but for FE model the impact is not significant. For the OLS model, a 1% increase in GDP per capita leads to a 0.00173% increase in the R&D intensity, ceteris paribus. This result means that if the economy of a country is growing, the energy companies of that country have a higher propensity to increase their R&D expenses (Kahouli, 2018).

Further, in the same table, it’s found that the rule of law has a positive relation with R&D intensity, but only in the OLS model. This relation is significant at the 10% level and a 1% increase in the rule of law leads to an 8.9% increase in the R&D intensity, ceteris paribus. This relation means the agents have confidence in and abide by the rules of society. In the case of Political Stability, it is negatively related to R&D intensity and is significant at the 10% level. This relation means that if the political instability decreases, then the R&D intensity of energy companies will increase, but only for the FE model.

In an increasingly globalized world in which political and other measures have consequences, even for those who are not necessarily covered by these constraints, an attempt was made to analyze whether all European countries, including those that are not part of the EU28, were affected by the 2030 Agreement that therefore addresses RQ1.

In order to address RQ2, a dummy variable of interaction, after2014*EU28, was created that equals one for companies headquartered in the EU28 and after the signature of the Agreement (in 2014), and zero otherwise.

The results are presented in Table 8. Although the results are not statistically significant at the 10% level, the sign of the variable is negative in both models (OLS and FE). This result can be interpreted as that the 2030 Agreement signed by EU28 countries is associated with a slight decrease in the R&D intensity of their companies in the energy sector.

Table 8: Ln R&D intensity, controlling for the 2030 Agreement and the EU28 headquarters firms

Variables	(1)	(2)
	ols	fe
After 2014*EU28	−1.467	−1.976
	(1.616)	(2.122)
L.lnRD intensity	0.709***	0.108
	(0.057)	(0.079)
L.ln RD intensity*after2014*EU28	0.0225	0.003
	(0.068)	(0.052)
Ln total assets	−0.0939**	−0.582***
	(0.036)	(0.177)
Ln total assets*after2014*EU28	0.064	0.0305
	(0.059)	(0.0711)
Cash flow	0**	−0
	(0)	(0)
Cash flow*after2014*EU28	−0	−0
	(0)	(0)
Deb tratio	−0.332	−0.456
	(0.303)	(0.481)
Debt ratio*after2014*EU28	−0.599	−1.415**
	(0.551)	(0.698)
GDP per capita	0.000	−5.62e-05
	(0.000)	(5.45e-05)
GDPpc*after2014*EU28	−0.000	6.48e-05
	(0.000)	(4.89e-05)
Political Stability	−0.092	−0.338
	(0.220)	(0.302)
Political Stability*after2014*EU28	−0.385	0.0341
	(0.542)	(0.659)
Rule of law	0.058	1.462
	(0.047)	(1.242)
RL*after2014*EU28	0.297	−0.720
	(0.322)	(0.674)
Time dummies	Yes	Yes
Constant	−0.049	8.957**
	(0.790)	(4.134)
Observations	557	557
R-squared	0.679	0.262
Number of company_id		95

Robust t-statistics are in parentheses. P<0.1*, P<0.05 **, P<0.01***. In columns 2 and 3, the outcome variable is logarithmic function of R&D intensity. LlnRDintensity is the logarithmic function of R&D intensity in period t-1. LnTotal Assets represent the logarithmic function of sum of total assets; long term receivables; investment in unconsolidated subsidiaries; other investments; and net property, plant, and equipment and other assets. Cash Flow is the sum of net income after taxes minus preferred dividends and general partner distributions plus depreciation and amortization of intangibles for fiscal period t. Debt ratio is the ratio between total debt and total assets of companies in period t. GDPpc represents the GDP per capita of the countries in period t. Political Stability measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism. Rule of law reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

Further, the logarithmic function of R&D intensity in the previous period is statistically significant at the 1% level in the OLS model. When analyzing the effect that the Agreement had on firms based in EU28 countries after 2014, the relation is no longer significant. However, the sign of the coefficient for Lln RD intensity*after2014*EU28 is positive which means the R&D intensity increases in EU28 headquartered companies relative to the previous period.

Based on the results of the regressions, the variable Ln Total Assets is a significantly negative at the 5% significance level in the OLS model with Ln R&D intensity and at the 1% significance level in the FE model. However, the effect of the Agreement on companies headquartered in the EU28 is not significant in the OLS and FE models. The same happens for the variable Cash Flows. In the OLS model, the variable Cash Flow is positive at the 5% level of significance, but in FE model it is negative and non-significant at the 10% level of significance.

In the FE model, the debt ratio has a negative and significant relation with R&D intensity that is significant at the 5% level. In another words, if energy companies have high values of R&D intensity, then the debt ratio of these companies is lower.

5. DISCUSSION

The questions that are related to climate change hotly debate matters such as innovation and how to rescue the planet (Calabrese et al., 2018). The energy sector, being one of the most pollutants, has made an effort to improve its polluting status through new energies and by increasing the efficiencies of traditional energies through investment in R&D (Toledano et al., 2020). There is more and more encouragement for green production and green innovation. According to Huang et al., (2019), the relation among companies, banks, and governments is becoming increasingly greater as governments guide the behavior of companies through effective interventions such as subsidies requiring green innovations, in which banks contribute through financing these innovation activities. In this study, we find that R&D intensity is positively associated to the previous period such as in (Alam et al., 2019; Su and Moaniba, 2020). This association means that R&D intensity depends very much on what happened in the previous period and not on external constraints. Also was found a positive relation between GDP and R&D intensity. This results corroborate those of Kocsis and Kiss, (2014), in the case of renewables energies.

Another finding that emerges from this study is the negative relation between R&D intensity and firms' size (Total Assets) that indicates that in energy sector, the largest companies have a lower propensity to pursue R&D due to its dominant position in the market that is an entry barrier for competitors. This finding corroborates the study of (Jiao et al., 2015). Nevertheless, analyzing the relation with R&D after 2014, we find a positive but non-significant relation for EU28 companies that overall, is still negative. The rationale behind this result is that the largest companies, being dominant in the market, have a preference to buy R&D instead of developing it in-house, because the returns are uncertain in the future.

Although not statistically significant, a difference in cash flows exists between companies headquartered in EU28 countries and the rest of Europe after 2014. In the EU28, the relation between cash flows and R&D intensity turns negative. However, in a model without controlling for location, this sample presents a significant and positive relation with R&D intensity that supports hypothesis 2 and the literature associated with this hypothesis.

We also find a negative relation between R&D intensity and the debt ratio, which is in line with what the literature has previously shown. For example, Ogawa (2007) emphasizes that high debt can lead to the risk of bankruptcy for companies and, as such, argues that if debt is high it has a negative impact on R&D. Meng et al. (2020) add the issue of access to credit that is conditioned to low levels of debt, and as such, the financing entities offer companies lower costs of debt compared to companies with higher levels of debt.

The results also highlight the questions related to political (in) stability in the energy companies. In particular, a lower instability could lead to increase R&D intensity. This increase means that the political environment can disturb the R&D intensity by affecting the uncertainty and costs related to R&D (Alam et al., 2019). The results obtained also raise questions about the perceptions of credibility of the government's commitment to such policies. The government's commitment may be a possible check as a change in the behavior of a country in which the environment of trust on the quality of formulation and implementation of policies and the credibility of the government's commitment to such policies decrease can be the reason why companies headquartered there decrease their R&D intensity also decrease. The rule of law has a positive relation with R&D intensity that gives investors' confidence and, in turn, less asymmetric information that lowers the costs of capital. Pindado et al. (2015) argue that strong legal systems that ensure minority shareholder protection or the protection of creditor rights provide investors with an environment where investing in R&D is more conducive.

Taking in consideration the effect of R&D intensity before and after 2014 signing of the 2030 Agreement, we find a decrease of R&D intensity, although not significant, after 2014. Based on the sign, the results of the study of Marino et al. (2019) match our findings. They also find evidence that the relation between regulation and innovation has an inverted U-shaped form. In our case, it can be interpreted that this regulatory measure associated with a decrease in R&D intensity. This sector is extremely regulated and a new legal imposition, even though in 2030, had a negative effect on R&D intensity, in the period under review. This form might mean that the effect of regulation on R&D intensity depends on the strength of the regulatory process. The research of Bassanini and Ernst, (2002) draws attention to the fact that there is a negative relation between the intensity of product regulation and the intensity of R&D expenditures.

6. CONCLUSIONS AND CONTRIBUTION

6.1. Main Findings

In this study, we provide a conceptual framework for the determinants of R&D intensity in the context of a policy change due to the 2030 Agreement. Consequently, the objective was empirically analyze the impact of the 2030 Agreement on R&D intensity on companies in the energy sector that were headquartered in the EU28. In a general way, the results diverge from the initial expectation because the Agreement did not bring an increase in R&D intensity to those companies. However, the same condition exists in the other European countries. Although we do not find a statistically significant change in the behavior of the R&D intensity, in the sample and based on the sign of the effect after 2014, this study supports the results of Marino, Parrotta & Valletta (2019) who argue that regulation shocks, instead of increasing innovation, decrease it (U-inverted).

Another fact that should be highlighted is the effect of the previous R&D intensity on the present period. In all models, the relation is statistically significant which means that R&D is sticky in terms of lags. This stickiness can be explained by the high costs in the energy sector with no guarantee of a safe return, as well as the fact that they are multi-year investment plans that do not fluctuate much from year to year. Therefore, the largest companies become immune to external legal changes. Unsurprisingly, we find a statistically significant and positive influence of R&D intensity in the previous year on the current year such as in Su and Moaniba, (2020).

Also, we find that R&D intensity relates to the size (Total Assets) of the companies. This relation is negative that indicates the largest companies have a lower propensity to pursue R&D. This lack is due to their dominant position in the market that becomes an entry barrier to competitors (Jiao et al., 2015). However, after 2014 in Europe the relation changes to positive that signals the commitment by EU28 companies to the Agreement and an alignment with the SDGs. But overall, this commitment is not enough to increase R&D in the energy sector.

The results also call the attention to the questions of perceptions of governance. The 2030 Agreement brought more political instability and a greater perception of the rule of law to the European countries that increased agency costs and decreased R&D investment, such as Wang et al. (2015).

Following the rationale of Makri et al. (2010), large companies prefer to buy technology already developed by start-ups that thus accelerates their adoption of new technology. Therefore, this decrease could be explained by 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 2030 Agreement, thus divesting them of developing new technologies or improving their energy efficiency. Another aspect that could justify these results is the possibility of national governments or the EU giving subsidies to the companies for research projects and that those funds are classified as a different accounting item. Another hypothesis is that R&D expenses are associated with very high fixed costs and, therefore, the changes in the behavior of these agents are not immediate. Based on these high fixed costs, these expenses have significant weights in the budgets of the companies, but R&D investment has a medium-term impact, so those decisions at a reporting level are not instantaneous.

Finally, the differences between companies based in EU28 or non-EU28 countries are marginal. The main difference occurs for Total Assets in companies headquartered in EU28 countries; Total Assets has a non-significant positive relation with R&D intensity as compared to a non-significant negative relation in non-EU28 countries. This relation means that companies with bigger Total Assets in the EU28 are more likely to invest more in R&D than companies in non-EU28.

6.2. Policy Implications

The contribution of this study is to understand the strategy adopted by companies in the energy sector with regard to R&D intensity by taking into account the effect of the 2030 Agreement on the EU28 countries. Bearing in mind that not investing in R&D can question the future of companies, it should create concern for shareholders. The results of this study may reflect a highly regulated sector where entry costs are high and where competition is not so high. So, governments need to lower the barriers to entry in the market to increase competition.

The implementation of this Agreement caused a decrease in R&D intensity in our sample, although the difference is not statistically significant. Therefore, governments need to create more incentives for companies to increase R&D intensity faster in order to achieve the targets of the 2030 Agreement and a sustainable economy. This goal should be possible through technology and energy consumption with a minor environmental impact with innovation a key factor (Fernandez Fernandez et al., 2018). The goals of the 2030 Agreement can be achieved by increasing the percentage of renewable energy consumption by increasing innovation (Sim, 2018), and reduce carbon dioxide emissions (Fernández Fernández et al., 2018). Since this sector is one of the most polluting, they should take the initiative to help mitigate climate change, if only because of the pressure of public opinion.

The results also highlight the questions related to political (in)stability. In this case, the change of regulation brought a disturbance to the political environment and the consequence was the decrease in R&D intensity because of uncertainty and the costs related to R&D (Alam et al., 2019). Further, in EU28 companies after 2014, although not significant, there has been a growth in the perception of the rule of law, although not significant.

In sum, to achieve the goals of the 2030 Agreement, companies and governments needs to improve the R&D investment to increase renewable energy consumption, improve energy efficiency, and reduce greenhouse gases in order to contribute to an alignment with the SDGs of the Agreement. This increase can be done in three ways: through incentives to companies (may be through subsidies or grants) or by creating penalizing measures for those who do not have acceptable levels of energy efficiency or low CO_2 emissions. The second way is to decrease the entry barriers and increase the competition in this highly regulated sector. The last way is to create an atmosphere of political stability and rule of law (contract enforcement) with strong incentives.

6.3. Main Limitations

Like any research, this study also has limitations. One limitation is the fact that the study focuses on companies in the energy sector in Europe, and the data on R&D spending is not available for all the listed companies of this sector. Therefore, we cannot generalize the results. In accounting terms, R&D can be classified in two ways: first as an asset from which the company expects to obtain future benefits and second as expenditures from which there is no certainty of obtaining future benefits. For these motives, it is not possible to make a generalization of the results, because they are based on expenditure information.

Due to the lack of data available, it is not possible to generalize the results because that not all EU28 countries are represented in the sample. The same happens with non-EU28 companies.

Hence, this investigation can only be generalized for companies in the stock market, as the features of those companies can diverge from non-traded companies. Therefore, further research is needed on the companies outside of this sample, like SMEs.

6.4. Further Research

Future studies need to collect data on companies of non-renewable energies because these companies must rethink their business because of the further agreements that will emerge regarding climate change. Due to the objectives of the 2030 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.

One possible explanation for our results is the fact that no distinction has been made in the type of company linked to the energy sector, and perhaps different behaviors in renewable energy companies exist compared to non-renewable energy companies in terms of R&D expenditures. Thus, this suggests the need for such a study.

For the energy sector it would be interesting to analyze the business strategy that these companies have as well as the type of management by observing factors such as the composition of the board or ownership structure.

Further, analyzing the behavior of R&D intensity in other markets such as China, India, or the US, since they are a major contributor to the pollution of the planet, could be of interest.

At last, since the energy sector has an important role in the economy, geopolitically, technologically, and environmentally, it is important to find out the reasons for the decrease in R&D spending in the European countries, especially in the EU28 countries, since the 2030 Agreement focuses on them.

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