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Financial crisis: Understanding the effects on European electric utilities' performance

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ABSTACT

During the 2008–2016 period, Europe experienced successive crises, namely the 2008–2009 global financial crisis, the 2010-2012 sovereign debt crisis and the 2014–2016 commodity prices crisis. The year 2010 therefore signalled the beginning of recovery in the financial markets, as well as the outset of significant economic and social changes. Having to deal with an increasingly challenging scenario driven by EU policies, European electric utilities (EEU) were heavily affected. This article intends to characterize the effects of financial crisis on EEU' business performance. It is assumed that corporate indicators may reflect the impact of the financial crisis on businesses. They can also help characterize the economic and social scenario that preceded the sovereign debt crisis. An analysis of the environmental, social, economic and financial data was performed, as generally reported by EEU in 2010. Using the Principal Components Analysis technique, a set of indicators was identified to represent the drivers and challenges of a particular period of time that was determining in upcoming developments. The results obtained made it possible to identify the most significant issues and the indicators with greater explanatory power that represent the concerns and priorities of the companies under study at the threshold between two successive crises.

Keywords:

European electric utilities;
Financial crisis;
Corporate indicators;
Principal components analysis;

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1. Introduction

"The last decade has been punctuated by a series of broad-based economic crises and negative shocks, starting with the global financial crisis of 2008–2009, followed by the European sovereign debt crisis of 2010–2012 and the global commodity price realignments of 2014–2016" (United Nations 2018).

Several economists consider the global financial crisis of 2008–2009 as the worst economic crisis since great depression of the 1930s [1]; [2]; [3]; [4]) due to its economic and social impacts. This "unprecedented event", given its "severity, speed and international scope lead to deep and protracted recessions in both developed and developing countries" ([4]; [1]; [5]). In fact, some authors also regard the global financial crisis as a determining contributor to the ensuing sovereign debt crisis in Europe [1]; [3]. Others, such as Geels [6], have presented a different perspective, proposing that the financial–economic crisis could involve the positive or negative impact on boosting sustainability transitions. The author concluded, "the early crisis years (2008–2010) created a window of opportunity for positive solutions" in order to promote sustainable development in the EU countries. The year 2010 marked the beginning of recovery from the global financial crisis. It also marked the emergence of the sovereign debt crisis, which mainly affected peripheral EU countries. Nonetheless,

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significant economic and social impacts propagated through the entire eurozone.

In 2010, the world economy showed timid signs of recovery, which presented different uneven patterns across countries. Western Europe's economies showed the first signs of emerging from the recession as early as the third quarter of 2009 [7], but economic activity was almost stagnant in most developed economies, while some developing countries presented better growth prospects [8], [7]. The recession brought a reduction in global demand, containment of financing, credit supplies and consequently an excess of unused productive capacity [7]. The banking crisis has forced the largest institutions in the banking sector to reduce access to credit, devaluate and clear their balance sheets [14], [6] and [3]. In this phase, the EU countries are generally characterized by weak labour markets with a reduction in employment and domestic demand [7],[3].

From a microeconomic perspective, the turbulence generated by the crisis has impacted the energy sector at two levels. It has affected the policy framework and it has brought new challenges for the agents operating in production, trading and distribution of energy.

By 2010, several trends were happening in the European energy sector, namely: liberalization and integration of the electricity and gas markets; concentration of private capital into mega clusters with a large diversification of activities; vertical integration and privatization of public companies. From 2010 onwards, there was: some stabilization of concentration movements; private financing of companies or groups with significant public shareholding; increased participation of citizens in corporate management; increased mobility of customers between electricity suppliers; arrival of new energy retailers with no connection with production assets on the market; increasing importance of Asian investment in the EU. However, in 2011, the EU remained quite dependent on fossil fuels for electricity production, with 51% of electricity generation coming from fossil fuels [15]. Other apparently abundant energy sources have been discovered worldwide in recent years. The exploitation of new sources of conventional and unconventional fossil fuels, namely shale gas and oil shale, has launched new players into the raw materials markets, changing the trade flows of primary energy and reorganizing the energy landscape.

Until 2012, the European economic scenario for electric utilities was characterized by some steadiness in trends. Electricity producers have to deal with decreasing demand, decreasing spreads for generation and funnelling of production subsidies towards renewable to the detriment of fossil fired generation [16]. In fact, the increase in the renewable share has helped lower the wholesale price of electricity, reducing the margins of thermal generation [17]. The prices for consumers remained the same due to renewable production subsidies. Thanks to incentives for decentralized production at household level, alternatives to centralized power generation and distribution emerged during the last years of the twentieth century and the first decade of the present century.

The previous points may lead to questions about how companies in the electricity sector have reacted to these changes and how they have affected corporate performance. Electric utilities are a good example as they have to handle challenges emerging on a global scale and by their own nature and scope they are intended to be accountable to various stakeholders. Because they provide a public service and have large-scale impacts, electricity companies have accrued responsibility for reporting to their stakeholders. A current challenge for companies is measuring social, environmental and economic performance, which, in the corporate scene, is considered fundamental for business success. Furthermore, corporations are recognized as significant actors of environmental disturbance due to direct and indirect action by producing social and economic effects. Therefore, the disclosed information is subject to careful scrutiny and analysis.

The objective of the present work is to understand the crisis' effect on the performance of electric utilities by identifying the indicators that are most representative of their situation in 2010, the year of the end of financial crisis and assumed to be a key year in the transition process in the European electricity sector. The analysis performed was based on an extensive set of data collected from the financial and non-financial reports published by selected companies, which brought together a selection of companies with the greatest representation at European level. An attempt was made to obtain a heterogeneous sample in terms of size, shareholder structure, business area and territorial coverage, which was comprehensive of the diversity of the European energy business community. The use of comparable, relevant and representative indicators for industry critical issues was taken as a suitable way of characterizing sector dynamics in a challenging context and to understand the moves and strategies of individual companies.

In order to condense a large amount of data into a set of indicators representative of the electricity industry with the least loss of information possible, multivariate techniques were used. The use of the Principal Components Analysis (PCA) technique identified, from a large set of indicators, those with the greatest explanatory power, which act as representatives of all the others. The methodology proved to be adequate and provided valuable outputs, making it possible to identify the most representative industry indicators in 2010.

The structure of the article comprises several sections. The first presents a brief literature review and presents the electric utilities scenario. In the second, following the previous explanation, a characterization of the panel is given. Next there is a brief presentation of the analysis method, its application to the panel, and a short discussion of the results. We conclude the article by signalling limitations and presenting avenues for future research.

2. Literature review

According to Jin et al [8], the treatment of company performance during the crisis and recovery has still not been adequately dealt with in the literature, and, in particular, firm-level treatment is lacking [2]. However, given the importance of the theme, a considerable body of literature has already been produced.

Jin et al [8] have performed a firm-level analysis to "define the recovery of firms' performance after the 2007–2008 global financial crisis", focusing "in particular on the relationship between firms' recovery and their financial constraints". Using a probit model, the authors found that companies with weaker financial constraints usually see faster recovery from the financial crisis than those with stronger constraints.

Zhao et al [1] have investigated the impact of the economic crisis, focusing on the financial performance of multinational corporations. They found that firms adopted aggressive commercial strategies and redirected their sales to Asian countries were less affected by crisis than other domestic counterparts.

Jin et al [8] have explored the recovery in the Market Value Added (MVA) of European companies after the global economic crisis in 2008–2009. Using a panel dataset, they aimed to "introduce empirical evidence that intangible-intensive strategy in human and relational capital reinforces speed of the after-crisis correction for companies". "The study demonstrates that intangible-intensive strategy did not always enable faster recovery speed, but provided year-on-year acceleration of MVA growth after the crisis."

Andriosopoulos et al [9] have researched the influence of events in financially troubled EU markets (Greece, Ireland and Portugal) on energy prices. They tested for contagion effects of bond prices on energy/commodity prices during the EU financial crisis, which was confirmed by the results. Sidhoum et al [10] have investigated the relationships among performance dimensions associated with corporate social responsibility (environmental, social and economic) regarding the U.S. electric utility sector. Using a statistical copula approach, they concluded utilities' economic performance is compatible with environmental, social, and governance performance.

As far as we know, references to the recovery of electric utilities have not been found in the available literature. However, Guerra-Mota et al [11] have performed an analysis using ANOVA to identify significant differences in corporate performance indicators during the pre-crisis period, crisis period and post-crisis period using a sample of European electric utilities. The Kruskal-Wallis test showed that variables relating financial and operational issues were the ones with the greatest differences during the period under analysis, which may be due to the very nature of the financial crisis.

From a methodological perspective, Jiang et al [12] have proposed a three-dimensional (economic, environmental, and social) sustainability assessment model to analyse corporate sustainable performance based on PCA. They concluded that the proposed method could assess a company's overall sustainability performance, and "that the method is theoretically sound and practically applicable". It was also suitable for uncovering strengths and weaknesses in order to define adequate strategies for improvement. Mota & Soares [13] have proposed the use of PCA to identify key performance indicators to assess the sustainability performance of European electric utilities. They concluded that the technique provided a valuable output when used to address environmental, social, economic and financial information generally reported by European electric utilities in order to "concentrate that information on a limited set of indicators, suitable for widespread application".

3. Context of the European electricity sector in 2010

The European electricity sector has always been very dynamic, in particular in the performance of mergers and acquisitions, and it also has a remarkable ability to adapt to increasing economic, social and environmental demands. Between 2000 and 2012, the European electrical sector underwent a period of mergers and acquisitions, mainly by consolidating large groups, trying to expand their markets, improving performances and achieving economies of scale in the generation, transmission and distribution segments. The European Union (EU) regulatory frameworks for the electricity sector, which stimulate both the operational efficiency and the increasingly complex new generation and transmission projects, helped consolidate these negotiations among domestic companies and allowing new players into national energy markets. In the context of the 2008–2011 crisis, the EU's economic objectives were: creating an integrated energy market (for electricity and gas); reducing the carbon footprint associated with the production of electricity; increasing energy efficiency; promoting energy independence and providing affordability of electricity. These needed well-defined political support to provide security to investors and businesses so they could correctly implement the measures [18,19].

To attain the defined objectives, the European regulatory framework's demand long-term investments relating to the decommission of the most polluting power plants, targets for renewable sources, and defined goals for gas emissions. This means that the electricity industry, which was a very capital-intensive sector, needed to maintain, increase or modernize its production capacity, investing in some cases in new technologies or markets [20].

The crises in the capital markets displaced private funds from the periphery to central European countries [16]. This brought about both difficult financing and credit access for economic agents, namely electricity players, and a change in the perception of the risk level in the electricity industry. Having to deal with increasing regulatory risk, high debts and narrow operating margins, electric utilities encountered increasing difficulties in financing themselves in the markets. However, electricity companies maintained the same level of investment in tangible assets while reducing financial investment [16]. In a fragile context for financing, most of the investment needs were covered by corporate debt.

A considerable number of mergers and acquisitions also contributed to restructuring and reshaping the European electricity and gas sector to face finance needs. Companies' main strategies consisted of concentrating assets in electricity and gas and focusing on vertical integration (generation, transmission and distribution), while continuing to control firms in other sectors [21]. Therefore, by 2010, several trends had been designed for European energy sector:

- Liberalization and integration of electricity and gas markets.
- Concentration of private capital in mega clusters with a large diversification of activities.
- Vertical integration – targeting activities in different areas of business in different companies, although they may belong to the same group (production, distribution and marketing). Enhanced productive capacity for most companies and the linking of several business areas in the same group.
- Privatization of national groups.

Some reforming countries have sold their public companies or admitted new players into national energy markets. These actions were supported by the view that increasing diversity in ownership could facilitate competition, provide comparability of performance and boost regulation [22]. Privatization can also provide significant immediate revenue for the government and reduce its future liabilities. On the other hand, they lose a strategic asset and a source of revenue. Privatization is not a necessary requirement for market liberalization and it is also questionable whether it is a condition needed to achieve better performance. Some companies in 2010 maintained a share of public ownership above 80%, such as Eesti (Estonia), EDF (France), Electricity Supply Board (Ireland), Eneco (Netherlands), Stratkraft (Norway), and Vattenfall (Sweden) (see Table 1).

However, some authors, such as Castro et al [21], expressed their concerns about this: "authorities are more cautious and more aware of companies' market power and their consequences for social welfare". Since energy markets were deregulated, the European Union "has not given emphasis to putting mechanisms in place to control moves towards concentration", considering that legislation and institutions did not follow the pace of market power concentration. This situation was particularly dramatic in the 2008–2012 crisis scenario, when decision-making and concerted strategies at EU level were urgently needed.

4. Generation utilities in EU scenario

The present study is mainly focused on European Union member countries, since they fall under an umbrella of global policies and goals for energy and under a common energy regulatory framework. However, some companies based in other European countries but outside the Union were also included in the study because the scope of their activities with EU member states means they are also subject to EU rules. The selected energy firms included both public and private entities, but also investor owned companies and cooperatives. The selection criteria were:

- Companies with headquarters in Europe, in order to limit the study to firms with a greater role in European territory.
- Companies with core business related to electricity production, although they could distribute their activities over a variable range of business areas (e.g., electricity production, distribution and transportation of gas and/or electricity, oil and gas exploration and production, sanitation and water supply, environmental services and others).
- Availability of non-financial information disclosed in published corporate reports (sustainability, citizenship, corporate responsibility or annual reports) or posted on the companies' websites.

Companies with unpublished non-financial information were excluded. Other exclusions were due

Table 1: EU generation utilities (corporate, production, financial and labour indicators)

Name	Headquarters	Installed generation capacity (MW)	Share of renewables in electricity generation	Revenue (10^6 Euros)	Employees	Share of Public Ownership
Acciona	Spain	7 587	97.26%	6 263	31 687	0.00%
BKW FMB Energy Ltd.	Switzerland	2 532	37.24%	2 586	2 914	52.54%
Centrica	UK	4 672	1.50%	25 114	34 969	0.00%
CEZ GROUP	Czech Republic	15 018	3.68%	7 954	32 627	69.78%
Dansk Olie og Naturgas A/S	Denmark	6 654	19.80%	7 331	5 874	75.00%
Drax	UK	4 000	0.00%	1 887	1 150	0.00%
Edison	Italia	12 586	0.00%	9 685	3 939	0.00%
Eesti	Estonia	n.a.	0.00%	796	2 608	100.00%
Electrabel	Belgium	11 233	3.13%	n.a.	7 213	0.00%
EDP Energias de Portugal SA	Portugal	21 990	64.43%	14 171	12 096	25.00%
Electricite de France SA	France	140 100	1.65%	65 200	158 842	84.48%
Electricity Supply Board	Ireland	5 600	0.00%	2 740	6 980	95.00%
EnBW Energie Baden-Wür AG	Germany	15 489	10.50%	17 509	20 952	46.55%
Endesa SA	Spain	40 141	35.48%	31 177	24 732	0.00%
Eneco	Netherlands	2 200	44.00%	4 922	6 545	100.00%
Enel Societa per Azioni	Italy	97 281	31.74%	73 377	78 313	31.20%
EON AG	Germany	68 475	10.00%	92 863	85 105	(*)
ESSENT	Netherlands	4 048	12.10%	6 120	5 872	0.00%
EVN	Austria	1 787	39.02%	2 752	8 536	51.00%
Fortum Corporation	Finland	14 113	41.28%	6 296	10 585	50.76%
Gas Natural Fenosa SA	Spain	17 305	17.79%	19 919	18 778	0.00%
Hafslund	Norway	NA	100.00%	2 018	1 123	53.73%
Iberdrola SA	Spain	44 991	30.12%	32 926	29 641	0.00%
International Power PLC	UK	70 196	0.00%	3 745	3 520	0.15%
NUON	Netherlands	3 645	8.44%	5 458	2 750	51.00%
Rwe AG	Germany	52 214	3.95%	47 741	70 856	(**) 5.1%
Scottish Southern Energy PLC	UK	11 330	15.71%	25 097	20 177	0.00%
Statkraft	Norway	16 010	88.50%	3 680	3 301	100.00%
Vattenfall AB	Sweden	39 923	22.72%	23 725	40 363	100.00%
Verbund AG	Austria	8 638	81.88%	3 308	3 096	51.00%

(Data referring to 31 December 2010)

Key: n.a. – data not available; (*) Information disclosed did not show the direct involvement of public entities; (**) Treasury shares to factors such as poorly quantified data in non-financial published reports or recent company integration into a group. In this last case, information on the company was usually reported in the consolidated group report.

The application of selection criteria for the end of the year 2010 resulted on the following list (Table 1).

In the 2010 European setting, it is difficult to identify energy sector companies engaged in a single key activity because they generally have vertically integrated businesses. Integrated businesses may include some or all processes from extraction of resources to product delivery to the customer, including processing, distribution and provision of support services. Alongside vertical integration, a strong trend has been seen towards a horizontal integration in the sector via the creation of partnerships and/or acquisition within the same market/ sector, both seeking an increase in size (market share) and taking advantage of possible economies of scale. Only 27% of the panel is devoted exclusively to activities related to production, trading or distribution of electricity, or perhaps associated with the production and distribution of heat. The remaining 73% combine the general electricity business with the trade, transportation and distribution of natural gas. On a smaller scale, some companies carry out fossil fuel extraction, provide environmental services, as well as construction and engineering activities, water supply, wastewater treatment and waste management services. Occasionally, selected companies may include telecommunications services (e.g., EVN, Hafslund and Scottish and Southern Energy).

About 40% of the selected companies carry out their activities in other continents beyond Europe, with significant participation in Latin American countries, especially by companies based in Italy, Spain and Portugal, which play a key role in the expansion of intercontinental energy businesses. Companies based in the northern and central European countries show a greater tendency for internationalization within Europe, expanding their business into neighbouring countries. There is still a non-negligible investment in electricity production in the U.S., particularly in the renewable sector, which, besides the southern Europe companies, also receives some contributions from the UK companies.

The selected panel comprises companies with diverse legal forms and ownership structure. The proportion of public shareholding is still relevant in the broader panel. Public ownership means the state or other public entities such as central, regional or local public authorities holding the company's share capital. Regarding 2010, about 20% of companies show a public shareholding of more than 80%, and 47% of the panel had a public contribution of more than 50% (Figure 1). These holdings are concentrated in northern and central Europe, since the energy business is considered a strategic investment and a structuring asset for the country and should be safeguarded from foreign interests. The countries in southern Europe and the United Kingdom have been withdrawing public shareholdings in their energy firms, leaving the energy business increasingly handed over to private initiative under the supervision of regulatory authorities. Electricity companies play a very important role in society since, besides the products and services they provide, they are also responsible for creating a large number of jobs. In 2010, 50% of the selected companies were individually responsible for more than 10,000 jobs each. A single company is responsible for over 100,000 jobs. About 27% of the panel is responsible for ensuring between 10,000 and 50,000 jobs. These numbers demonstrate a particular responsibility from the industry to society.

As previously mentioned, the production of electricity has a significant impact on the level of greenhouse gas emissions and on the consumption of natural resources. The use of renewable energy sources has been promoted in a bid to help minimize these effects and to reduce the negative contribution of electricity production in environmental terms. However, despite all the efforts made at EU level to promote renewable energies, in 2010, 34% of the selected companies still produced less than 5% of their electricity using renewable energy sources. The panel comprises the largest and most representative producers of electricity in Europe and 60% of them still use less than 20% of renewable sources in their electricity production. Only 13% of the

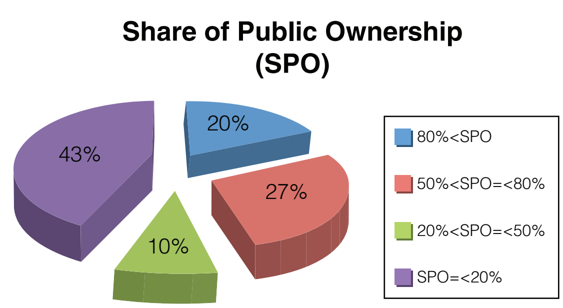

Figure 1: Share of public ownership (SPO)

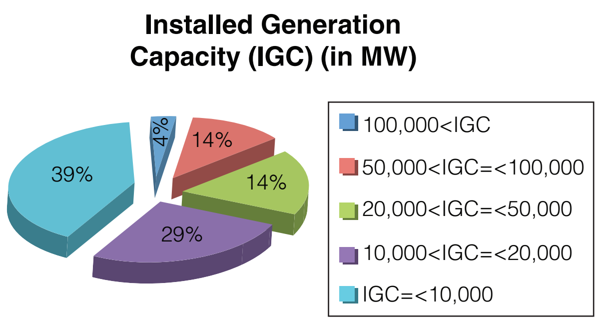

Figure 2: Installed generation capacity (ICG)

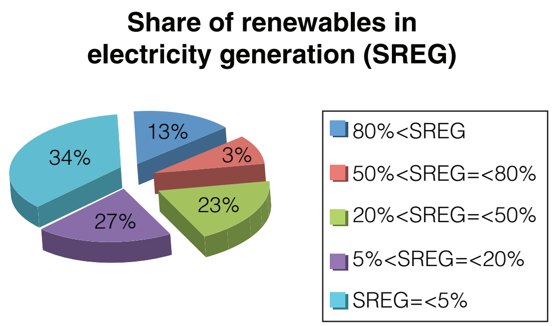

Figure 3: Share of renewables in generation (SREG)

selected companies produce more than 80% of their electricity from renewable sources (Figure 3).

In late 2010, about 70% of the selected companies had an installed capacity under 20,000 MW, of which more than half had less than 10,000 MW. The analysis of company or group reports showed that companies with more than a 30% share of renewables in their energy mix represent 55% of companies with an installed capacity of less than 20,000 MW and of these 66% had an installed capacity of less than 10,000 MW (Figure 2). Production using renewable sources is more valued in smaller companies. However, the same table reveals that all the larger companies with shares of renewable higher than 30% are concentrated in southern Europe. Portugal, Spain and Italy lead the investment in renewable sources in terms of large-scale production, which might indicate a closer alignment of corporate strategies with global environmental concerns.

5. PCA application and results

The main goal of this research is to contribute for understanding the position of electric utilities in 2010 that conditioned their subsequent development path up to now.

Based on available data and key industry issues, a panel of mixed physical and monetary indicators was drawn up, covering the environmental, social, economic and financial dimensions of electric utilities' corporate performance. The use of absolute indicators makes it difficult to make comparisons between companies with very different scales and may induce distortions in the results. The relativization of indicators made it possible to control several problems that could arise during data analysis. The authors proposed the use of a set of 52 composite indicators, relativized according to dimension (size and production capacity), referring to environmental, economic, social and financial issues. It was intended for them to provide adequate benchmarking for the companies under study regardless of their differences.

The variables were selected bearing in mind the concern for all variables to be independent and metric [23]. Thus, dummy variables and those with an explanatory relationship between them were excluded. Relative indicators are presented in Annex A.

A very wide set of variables, although providing a large amount of information, usually ends up being difficult and complex to interpret by users. However, some variables are naturally linked, presenting similar behaviour. For example, it is expected that increases in production capacity will be accompanied by a change in revenue in the same direction. The overlapping of some variables is more likely to occur in a large set of variables than in a set with few variables, which may remain distinct and different. So a large number of variables that expresses a particular situation can be replaced by a smaller group that maximizes the explanation of the entire data set. Factor analysis (FA) techniques make it possible to understand the structure and interrelationships of a wide number of variables addressed in multivariate techniques [24]. In the present research, FA is used within an exploratory perspective to search for a structure among a set of variables. There are not any constraints or preconceived thoughts defined a priori relating to an expected structure, number of components, or any hypothesis to test. When dealing with FA, it is desirable for there to be a relevant degree of multicollinearity to assure the production of representative factors. Multicollinearity broadly means that variables are intercorrelated through the existence of one or several linear relationships among them. Multicollinearity is perfect if the variable can be derived through a linear combination of other variables with a stochastic error term of zero. Imperfect multicollinearity means that one variable may be partly explained through a linear combination of other variables and a stochastic error term different from zero [25]. Principal Components Analysis (PCA) is a descriptive procedure used to reduce a vast data set into a small number of components. Implementation of the technique passes through several phases: intercorrelation testing, selection of variables and interpretation of components. In this research, EVIEWS software was used to estimate PCA for each dimension of corporate performance. The use of the eigenvalue criteria makes it possible to select the first principal components (PCs), which apprehend 80% of the total variance. The contribution to explaining total variance assumes a decreasing importance from component one (PC1) to component n (PC n).

As regards financial issues (Table 2), of the four extracted components, there is a valuation of the issues related to returns on assets, which explains almost 48% of variance.

In the first component (PC1), the most relevant issues are those relating to business profitability, mainly return on assets, but also the profitability of investments, revenues and equity. PC1 provides information about the use of assets and indirectly makes it possible to assess whether the investment in assets is appropriate to the needs of the company and whether it is being properly monetized.

The demand for a balanced financing structure represents almost 22% of the explained variance of PC2. The sum of the two first components accounts for approximately 60% of the total variance of financial issues. This means that the two first components are characterized for issues related both to proper use of assets and the creation of a financing structure that enables an adequate return on the capital. The remaining components relate to other themes such as financial coverage and reliance. The joint vision of the four principal components fundamentally refers to the issues connected to return on capital, such as indebtedness, return on assets (reflecting the company's management with respect to its productive capacity), results generation and the balance of financial structure. Volatility appears as a sign of instability and risk associated with business strategy and profitability. Other financial issues that are also relevant to the sector were not included due to insufficient workable data. For example, some matters pertinent to the electricity industry, such as the financial assistance received from government, fit into this category.

As for social issues (Table 3), of the five extracted components, the variables related to the stability of employment contracts and the proportional distribution of the factors of production (capital and labour) remuneration were identified as the most representative.

Individuals' professional development, fairness in leadership positions, and occupational safety and health, job stability, career development and motivation are also relevant. Women in business have taken an interesting role when related to staff turnover, absenteeism, seniority and health at work, appearing with three high loadings in five components. The electricity generation sector has demonstrated a trend over the past six years to reduce its headcount. Increased female employment may generate more revenue, but with fewer social charges. This

Table 2: Principal Component Analysis (PCA) for financial indicators

Variable	PC1	PC2	PC3	PC4	
DV_YLD	0.104055	0.047782	0.460426	0.521596	
E_PS	−0.022930	−0.153716	−0.454015	0.601025	
IEBIT	0.318156	−0.465089	0.211888	−0.112725	
IEBITDA	0.326580	−0.463464	0.071086	−0.123937	
IDBT	−0.005324	0.206430	0.601325	−0.206721	
IT_LBL_EQT	−0.086072	0.071273	−0.216304	−0.279466	
ROA	0.518207	−0.024538	−0.043558	0.009318	
ROE	0.325750	0.493832	−0.095708	−0.070607	
ROI	0.402074	0.481925	−0.130173	0.024646	
ROR	0.486326	−0.085263	−0.106423	0.060073	
VOL	−0.022472	0.106277	0.290209	0.456636	
Proportion (of total variance)	**0.359400**	**0.162200**	**0.122000**	**0.095700**	**0.739300**
Corrected proportion	**0.486136**	**0.219397**	**0.165021**	**0.129447**	**1.000000**

Table 3: Principal Component Analysis (PCA) for social indicators

Variable	PC1	PC2	PC3	PC4	PC5	
IEMP_ABS	−0.047369	−0.133604	0.174939	0.057930	0.738848	
IEMP_ACC	−0.193375	0.371412	−0.451646	0.206549	−0.015907	
IEMP_FTC	0.464692	−0.146493	0.297068	0.066184	−0.003379	
IEMP_PC	0.464557	−0.114754	0.226856	0.147853	−0.066541	
IEMP_SEN	0.351480	−0.206607	−0.337809	0.159632	0.209068	
IEMP_TRG	0.248666	0.481574	−0.052267	0.355860	−0.094145	
IEMP_TURN	−0.180157	−0.105132	0.299558	0.520551	0.144272	
IEMP_WOMB	0.043686	0.505113	0.168746	−0.167609	0.297280	
IEMP_WOMT	−0.241147	0.212659	0.342033	0.480689	−0.103930	
IEMP_WONM	0.175158	0.278708	−0.149331	−0.022954	0.475829	
IEMP_FAT	0.158741	−0.117058	−0.425560	0.172957	0.074805	
ITAX	0.155732	0.322130	0.264139	−0.439815	−0.053363	
IWAGE	−0.413024	−0.168554	0.022035	−0.147024	0.204916	
Proportion (of total variance)	**0.291600**	**0.197100**	**0.136800**	**0.107900**	**0.101200**	**0.834600**
Corrected proportion	**0.349389**	**0.236161**	**0.163911**	**0.129283**	**0.121256**	**1.000000**

component also reflects the interest of the organization in retaining skilled labour and talent. The identified components fundamentally relate to employment issues, given that this was the only social area with enough information in the panel to be considered in the analysis. Other social issues also relevant to the sector were not included due to insufficient workable data. For this reason, some relevant matters were not included in the analysis: those regarding wage variability in different geographical areas, basic salary ratio between men to women, local hiring, integration of local senior managers, union conflicts, contributions to communities, wages compared to local minimum wage at significant locations of operation, people's displacement resulting from setting up or expanding production facilities, contributions to political parties and politics, policy positions.

As regards environmental issues (Table 4), of the four extracted components, there is a valuation of issues related to air pollution and production mix, which explains almost 37% of the corrected variance. Generation sources and gas emissions represent almost 27% of the explained variance. The rest relates to others themes such as environmental expenditure (costs and nature of investment) and treatment of hazardous waste.

Air emissions take an important role when related to production structure and environmental investments, appearing with two high loadings in four of five components. The identified components relate essentially to production issues, given that this was the only environmental area with enough information in the panel to be considered in the analysis. Other environmental issues also relevant to the sector were not included due to insufficient workable data. For example, this situation includes some matters pertinent to the electricity industry, such as the impact on biodiversity, nuclear waste production, water contamination, the impact of dams and reservoirs on ecosystems and the flooding of agricultural land, water sources significantly affected by withdrawal of water, habitats protected or restored, total water discharge by quality and destination, monetary value of significant fines for non-compliance with environmental laws and regulations.

Regarding economic issues (Table 5), of the five extracted components, issues related to the social distribution of economic value (among stakeholders) were valued, which explains almost 23% variance. Efficiency issues of thermal processes are presented in two different views.

On the one hand, efficiency is envisaged through the market's valuation of heat as a commercial product and on the other efficiency stems from fuel use and technological solutions. Efficiency issues represent a total of 35% of the explained variance for economic factors. The sum of the first three components accounts for approximately 58% of the total variance of economic issues. The remainder relate to other themes such as labour productivity, market, earnings linked to technological options, externalities and the ability to ensure loan compliance. The identified

Table 4: Principal Component Analysis (PCA) for environmental indicators

Variable	PC1	PC2	PC3	PC4	
IEXPENV_RVN	0.080602	−0.058676	0.536090	0.256541	
IGENNU_T	−0.178032	−0.053694	0.431875	−0.236145	
IGENRE_T	−0.251426	0.401488	−0.274671	0.225782	
IGENRENU_T	−0.397648	0.354087	0.043605	−0.001312	
IWST_REC_NZ	−0.317179	−0.127024	0.126759	0.242954	
ICO_TEQ	0.254598	−0.300943	−0.205307	0.264481	
ICO_TH	−0.009158	0.035758	−0.542528	0.223726	
ISO_T	0.373536	0.396999	0.108425	0.019317	
INOX_T	0.348679	0.399944	0.111517	0.089253	
IPART_T	0.369000	0.376072	0.066866	0.021929	
IWST_ZREC	−0.086061	−0.012488	0.249739	0.724909	
IWST_Z	−0.155089	0.164389	0.071631	−0.328721	
IGENTH_T	0.382409	−0.336082	−0.005204	−0.077727	
Proportion (of total variance)	**0.297300**	**0.217900**	**0.157500**	**0.138000**	**0.810700**
Corrected proportion	**0.366720**	**0.268780**	**0.194277**	**0.170223**	**1.000000**

Table 5: Principal Component Analysis (PCA) for economic indicators

Variable	PC1	PC2	PC3	PC4	PC5	PC6	
IT_RVN	−0.221070	−0.216369	−0.401619	0.019459	0.283615	0.397800	
ICAPEX	0.058502	−0.034764	0.043592	−0.299543	0.215709	0.233684	
IPEC_CN	−0.202241	0.070976	−0.297382	0.173520	0.294828	−0.329827	
IPDTV	−0.176197	0.237134	0.113678	0.449820	−0.160478	−0.099222	
IWA	0.072015	0.224946	0.044014	−0.148229	0.621431	−0.063197	
IH_GENTH	0.078440	0.605835	−0.207644	−0.285086	−0.265194	0.020087	
ISAL_ELCOS	0.346051	0.487464	0.067682	0.021955	0.142154	0.363307	
IGENT_SAL	0.194209	0.131126	0.198777	0.474156	0.078127	−0.210189	
IEVD_EMP	0.418139	−0.026043	0.165711	0.224950	−0.029473	0.245152	
IEVD_LEN	0.270949	−0.094055	−0.143741	0.187648	−0.055777	0.487821	
IEVD_OWN	0.304693	0.244096	−0.019119	−0.003724	0.401365	−0.146893	
IEVD_TAX	0.477387	0.243208	−0.007375	0.193080	0.012471	0.097317	
ISELF_T	−0.032166	0.188172	0.490842	−0.267809	−0.134590	0.188840	
IBYPRO	−0.187049	−0.192718	0.583119	0.077690	0.305075	0.111096	
IRVN_EMP	−0.387715	0.132088	−0.129621	0.384748	0.033544	0.332908	
Proportion (of total variance)	**0.178400**	**0.143500**	**0.129200**	**0.125100**	**0.109200**	**0.093200**	**0.778600**
Corrected proportion	**0.229129**	**0.184305**	**0.165939**	**0.160673**	**0.140252**	**0.119702**	**1,000000**

components essentially relate to those relevant issues with enough information in the panel to be considered in the analysis. Other economic matters also relevant to the electricity production sector were not included due to insufficient workable data. For example, this situation includes some matters pertinent to the electricity industry, such as the proportion of spending on locally based suppliers and the energy saved due to conservation and efficiency improvements.

Of the initial 52 indicators used in former PCA, the 19 with the highest loadings are then presented (see Table 6)

6. Conclusions and further research

The global financial crisis had a direct impact on business financing, access to credit and investment, demanding the appropriate definition of corporate

Table 6: Summary of aggregated variables from PCA

Dimension	Variables	Dimension	Variables
Economic	Cooling water used per unit of electricity generated	Financial	Earnings per share
Economic	Weight of heat generation in total electricity generation	Financial	Weight of net debt in total assets
Economic	Weight of electricity generation in total electricity sales	Financial	ROA Return on assets
Economic	Weight of payments to lenders in Economic Value Distributed	Financial	ROE Return on equity
Economic	Weight of taxes (income and others) in the Economic Value Distributed	Social	Employee absenteeism rate
Environmental	Proportion of recovered by-products (gypsum and ash)	Social	Average accidents per one hundred employees
Environmental	Share of renewable sources in electricity production	Social	Proportion of employees with full-time contracts
Environmental	Proportion of CO_2-free electricity production	Social	Proportion of women on the management board
Environmental	CO_2 relative emissions from electricity generation (Kg per kWh)	Social	Proportion of employees replaced within the company, excluding retirements
Environmental	Proportion of recovered hazardous waste	------ -----	------ ------

strategies and action plans [26]. In this way, the effects of crisis also influenced the companies at economic, social and environmenl level, having repercussions on their global performance. The article assumes that the identification and analysis of the most important corporate indicators of electric utilities allows apprehending the effects of a complex scenario in their performance. A heterogeneous sample, referring installed generation capacity, share of renewables in electricity generation, revenue, number of employees and share of public ownership, was used in the study.

After the methodology was applied, the dimensions of corporate performance were characterized in terms of the established indicators. In the case of European electricity production, these dimensions are highlighted comprehensively by:

Return on assets, equity and debt capital concerns characterize economic and financial dimensions. These concerns are expressed though the leading role of the following indicators: ROA (Return on assets); ROE (Return on equity); Weight of net debt in total assets.

Efficiency of production technologies characterizes economic and environmental dimensions. These concerns are expressed though the leading role of the following indicators: Weight of heat generation in total electricity generation; Weight of electricity generation in total electricity sales; Share of renewable sources in electricity production.

Efficient uses of resources characterize economic and financial dimensions. These concerns are expressed though the leading role of the following indicators: Cooling water used per unit of electricity generated; Proportion of recovered by-products (gypsum and ash); CO_2 relative emissions from electricity generation.

Equity in the distribution of economic value generated by the stakeholders characterizes economic and social dimensions. These concerns are expressed though the leading role of the following indicators: Weight of payments to lenders in the Economic Value Distributed, Weight of taxes (income and others) in the Economic Value Distributed, Earnings per share.

Working conditions, relating to employment contracts and health and safety, characterize the social dimension. These concerns are expressed though the leading role of the following indicators: Employee absenteeism rate; Average accidents per one hundred employees; Proportion of employees with full-time contracts.

Contribution of women to production and management also characterizes economic and social dimensions and this concern is expressed though the leading role of the following indicator: Proportion of women on the management board.

Pollution concerns characterize the environmental dimension. These concerns are expressed though the leading role of following the indicators: Proportion of CO2-free electricity production; Proportion of recovered hazardous waste.

Other industry critical issues were not considered due to the lack of a minimum number of observations required to implement the Factor Analysis (FA) technique or because they simply were not reported by a representative group of companies (e.g., nuclear waste, liquid water use, impacts on biodiversity, links to local communities).

The context of the energy sector was by itself, in 2010, a scenario of change. That makes difficult to differentiate the impact of the crisis on the performance of companies from the impact of other external factors. However, the purpose of the article is to understand the situation of electric utilities at the end of the financial crisis. The analysis identified the most representative indicators of business performance in 2010 and the relationships between them, at a particular moment of time that coincides with the end of the financial crisis. Obtained results are aligned with the concerns and trends exposed in former sections.

Further research is important to determine if the results persisted in subsequent years or if, in the course of the ongoing challenges posed to electric utilities, they significantly changed.

References

[1] Zhao, Xin; Jiang, Xianling; Li, Zhaoyang The impact of the economic crisis on the financial performance of multinational corporations, International Review of Economics & Finance, Volume 37, 2015, Pages 55–68, ISSN 1059-0560, https://doi.org/10.1016/j.iref.2014.11.013.

[2] Barajas, Angel; Shakina, Elena; Fernández-Jardón, Carlos. Acceleration effect of intangibles in the recovery of corporate performance after-crisis. Research in International Business and Finance 42 (2017) 1115–1122. http://dx.doi.org/10.1016/j.ribaf.2017.07.046

[3] Moro, Beniamino. Lessons from the European economic and financial great crisis: A survey. European Journal of Political Economy 34 (2014) S9–S24, http://dx.doi.org/10.1016/j.ejpoleco.2013.08.005

[4] Pentecôte, Jean-Sébastien; Rondeau, Fabien. Trade spillovers on output growth during the 2008 financial crisis, International Economics, Volume 143 (2015), Pages 36-47, ISSN 2110-7017. https://doi.org/10.1016/j.inteco.2015.04.003.

[5] Lungu, Camelia Iuliana; Caraiani, Chirata; Dascalu, Cornelia; Guse, Raluca Gina. Exploratory Study on Social and Environmental Reporting of European Companies in Crises Period," Journal of Accounting and Management Information Systems, Faculty of Accounting and Management Information Systems, The Bucharest University of Economic Studies, vol. 10(4), pages 459-478, (2011). December.

[6] Geels, Frank W. The impact of the financial–economic crisis on sustainability transitions: Financial investment, governance and public discourse. Environmental Innovation and Societal Transitions 6 (2013) 67–95. http://dx.doi.org/10.1016/j.eist.2012.11.004

[7] United Nations (2010b). World Economic Situation and Prospects 2010. Update as of mid-2010(United Nations publication, Sales No. E.10.II.C.2),

[8] Jin, Yuying; Luo, Mingjin; Wan, Chao. Financial constraints, macro-financing environment and post-crisis recovery of firms. International Review of Economics and Finance 55 (2018) 54–67. http://dx.doi.org/10.1016/j.iref.2018.01.007

[9] Andriosopoulos, Kostas; Galariotis, Emilios; Spyrou, Spyros. Contagion, volatility persistence and volatility spill-overs: The case of energy markets during the European financial crisis. Energy Economics 66 (2017) 217–227. http://dx.doi.org/10.1016/j.eneco.2017.06.023

[10] Sidhoum, Amer Ait; Serra, Teresa. Corporate social responsibility and dimensions of performance: An application to U.S. electric utilities. Utilities Policy 48 (2017) 1-11 http://dx.doi.org/10.1016/j.jup.2017.06.011

[11] Guerra-Mota, Marta; Soares, Isabel; Aquino, Thereza. "European electricity utilities managing energy transition challenges" (Book of proceedings of ICEE - 3rd International Conference on Energy & Environment: bringing together Economics and Engineering). Faculty of Economics, University of Porto. (2017)

[12] Jiang, Qiuhong; Liu, Zhichao; Liu, Weiwei; Li, Tao; Cong, Weilong; Zhang, Hongchao; Shi, Junli. A principal component analysis based three-dimensional sustainability assessment model to evaluate corporate sustainable performance. Journal of Cleaner Production 187 (2018) 625-637. https://doi.org/10.1016/j.jclepro.2018.03.255

[13] Mota, Marta; Soares, Isabel. "Sustainability indicators for Electric Utilities: a proposal using PCA". Book of proceedings of 1st International Conference on Energy & Environment, Faculty of Economics, University of Porto (2013)

[14] United Nations (2010a). World Economic Situation and Prospects 2010 (United Nations publication, Sales No. E.10.II.C.2), released in January 2010.

[15] Eurelectric. Power Statistics & Trends 2012 Edition (2012). http://www.eurelectric.org/powerstats2012
[16] Eurelectric. The financial situation of the Electricity Industry – Economic and financial update. june (2013) http://www.eurelectric.org/media/81890/fg_fe_paper__final-2013-540-0004-01-e.pdf
[17] Verbruggen, A. et al. Europe's electricity regime: restoration or thorough transition. International Journal of Sustainable Energy Planning and Management Vol. 05 (2015) pages 57–68. http://dx.doi.org/10.5278/ijsepm.2015.5.6
[18] EC European Commission's communication. Energy roadmap 2050. COM(2011) 885 final of 15 December (2011) http://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX:52011DC0885&from=EN
[19] Vasconcelos, Jorge. Política Europeia de Energia. Conferência sobre Energia Eléctrica de Fontes Renováveis EEFoR, FEUP (2013)
[20] Genoese F,; Egenhofer C. Reforming the market design of EU electricity markets – addressing the challenges of a low-carbon power sector. CEPS Task Force Report, July (2015). https://www.ceps.eu/publications/reforming-market-design-eu-electricity-markets-addressing-challenges-low-carbon-power
[21] Castro, Nivalde J.; Leite, André Luís da Silva; Soares, Maria Isabel. Electric sector mergers and acquisitions: lessons from the European Union. FEP Working paper (2008)
[22] Jamasb, Tooraj; Pollitt, Michael. Electricity Market Reform in the European Union: Review of Progress toward Liberalization & Integration. Energy Journal. 11-41, Apr. 2, (2005). http://web.a.ebscohost.com/ehost/detail/detail?vid=0&sid=bb46dbb2-f0a7-40ec-8f63-83d2bd7c2efd%-40sessionmgr4008&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=a9h&AN=19750395
[23] Guerra-Mota, Marta. On Corporate Sustainability Reporting - Case of Electric Utilities. Phd Thesis. Faculty of Engineering, University of Porto. (2013) Available on: http://hdl.handle.net/10216/723152013
[24] Hair, Joseph F. Multivariate Data Analysis. Prentice Hall; 7th edition (2009)
[25] Gujarati, Damodar N. "Basic Econometrics". Second Edition. New York: McGraw-Hill. (1998)
[26] Aras, Güler; Crowther, David. (2009), "The Durable Corporation in a time of Financial and Economic Crisis", Journal of Economics & Management, Vol. 14, No 3, pp. 211–217. 25049

Annex A

Relative financial indicators

Symbol	Unit	Formulation	Name
FINANCIAL			
IEBIT	ratio	iebit = ebit/t_ass	Weight of EBIT in total assets
IEBITDA	ratio	i_ebitda = ebitda/t_ass	Weight of EBITDA in total assets
IDBT	ratio	i_dbt = n_dbt/t_ass	Weight of net debt in total assets
IT_LBL_EQT	ratio	it_lbl_eqt = t_lbl/t_eqt	Weight of total liabilities in total equities
DV_YLD*	Euro	dv_yld = dividend per share/price per share	Dividend Yield
E_PS*	Euro	e_ps = income to equity shareholders/no. of common shares outstanding	Earning per share
ROA*	ratio	roa = net income/t_ass	Return on assets
ROE*	ratio	roe = income to equity shareholders/average shareholder equity	Return on equity
ROI*	ratio	roi = operational results/t_assets	Return on investment
ROR*	ratio	ror = net income/t_rvn	Return on revenue
VOL	ratio	(see formula)	Annualized volatility

Relative economic indicators

Symbol	Unit	Formulation	Name
ECONOMIC			
IPEC_CN	Tj/GWh	ipec_cn = pec_cn/el_gent	Primary energy consumption per unit of electricity generated
ISELF_T	%	iself_t = el_self/el_gent	Proportion of produced electricity used for self-consumption
IWA	10^3 m^3/GWh	iwa = wa_coo/el_gent	Cooling water used per unit of electricity generated
IBYPRO	%	ibypro = bypro_rec/bypro	Proportion of recovered by-products (gypsum and ash)
IH_GENTH	%	ih_genth = h_gen/nel_genth	Weight of heat generation in total electricity generation
IPDTV	GWh/employee	ipdtv = el_gent/emp_t	Electricity generation per employee
IGENT_SAL	%	igent_sal = el_gent/elt_sal	Weight of electricity generation in total electricity sales
ISAL_ELCOS	GWh/costumer	isal_elcos = elt_sal/el_cos	Electricity sales per costumer
IRVN_EMP	10^6 €/employee	irvn_emp = t_rvn/emp_t	Revenue per employee
IT_RVN	%	it_rvn = t_rvn/t_ass	Weight of total revenues in total assets
ICAPEX	%	icapex = capex/t_ass	Weight of capital expenditures in total assets
IEVD_EMP	%	ievd_emp = evd_emp/dev_d	Weight of wages, salaries and benefits in EVD[1]
IEVD_LEN	%	ievd_len = evd_len/dev_d	Weight of payments to lenders in EVD
IEVD_OWN	%	ievd_own = evd_own/dev_d	Weight of payments to owners in EVD
IEVD_TAX	%	ievd_tax = evd_tax/dev_d	Weight of taxes (income and others) in EVD

[1]Economic Value Distributed (EVD)

Relative environmental indicators

Symbol	Unit	Formulation	Name
ENVIRONMENTAL			
IEXPENV_REV	%	iexpenv_rev = env_exp/t_rvn	Weight of environmental expenditure in revenues
IGENTH_T	%	igenth_t = nel_genth/nel_gent	Share of thermal sources production in electricity production
IGENNU_T	%	igennu_t = nel_gennu/nel_gent	Share of nuclear sources in electricity production
IGENRE_T	%	igenre_t = nel_genre/nel_gent	Share of renewables sources in electricity production
IGENRENU_T	%	igenrenu_t = (nel_genre+nel_gennu)/nel_gent	Share of CO_2 free electricity production
ICO_TEQ	Kg/kWh	ico_teq = co_teq/el_gent	CO_2 equivalent relative emissions from electricity generation
ICO_TH	Kg/kWh	ico_th = co_th/el_gent	CO_2 relative emissions from electricity generation
INOX_T	g/kWh	inox_t = nox_t/el_gent	Particles relative emissions from electricity generation
IPART_T	g/kWh	ipart_t = part_t/el_gent	NOx relative emissions from electricity generation
ISO_T	g/kWh	iso_t = so_t/el_gent	SO_2 relative emissions from electricity generation
IWST_REC_NZ	%	iwst_rec_nz = wst_nzrec/wst_nz	Proportion of recovered non hazardous waste
IWST_ZREC	%	iwst_zrec = wst_zrec/wst_z	Proportion of recovered hazardous waste
IWST_Z	%	iwst_z = wst_z/wst_t	Proportion of hazardous waste in total waste

Relative social indicators

Symbol	Unit		Name
SOCIAL			
IEMP_ACC	‰	iemp_acc = 1000*emp_acc/emp_t	Average accidents per one hundred employees
IEMP_FAT	‰	iemp_fat = 1000*emp_fat/emp_t	Average fatalities per one hundred employees
IEMP_FTC	%	iemp_ftc = emp_ftc/emp_t	Proportion of employees with full-time contract
IEMP_PC	%	iemp_pc = emp_pc/emp_t	Proportion of employees with permanent contract
IEMP_TRG	hours	iemp_trg = emp_trg/emp_t	Hours of training per employee
IEMP_ABS*	%	iemp_abs = number of absent days /the number of available workdays	Absenteeism rate
IEMP_SEN*	years	iemp_sen = sum of years of employees permanence in the company/emp_t	Average seniority (permanence in the company)
IEMP_TURN*	%	iemp_turn = number of employee leaves/ average number of employees	Proportion of employees replaced within the company, excluding retirements (staff turnover)
IEMP_WOMT	%	iemp_womt = emp_womt/emp_t	Proportion of women in total workforce
IEMP_WONM	%	iemp_wonm = emp_wonm/emp_t	Proportion of women in management
IEMP_WOMB	%	iemp_womb = emp_womb/emp_t	Proportion of women on the board
ITAX	%	itax = evd_tax/t_rvn	Weight of tax in revenues
IWAGE	%	iwage = evd_emp/evd_own	Weight of wages, salaries and benefits in payments to owners