Data processing at the European level in the TERAIN database: A smart dashboard prototype for corporate environmental performance assessment

Toxic Environmental Risks Analytical Intelligence

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1 Introduction

The Toxic Environmental Risks Analytical Intelligence database (from now on abbreviated as TERAIN) is a screening-level dashboard that assesses the corporate environmental performance (CEP) of the European and American companies that engage in polluting industrial activities. TERAIN offers an easy, simple, and intuitive way to evaluate environmental risks through the pollutant emissions of a facility, company, or region. It does so using up to nine environmental performance indicators (EPIs) reflecting the amount of chemical substances that are yearly reported to the official mandatory registers in Europe and the US.

In other words, TERAIN delivers processed data extracted from the European Pollutant Release and Transfer Register (E-PRTR), and the EPA's Toxic Release Inventory (TRI). And it allows its users to choose the consultation time period, longitudinally or transversely, and the type of emissions that they will assess. This is possible thanks to TERAIN's Environmental Impact Scores, nine EPIs that aggregate the pollutants in the E-PRTR, and the TRI according to their toxicity weighting factors. In this way, TERAIN aims to simplify EPIs and environmental risk ratings through data that is easy to consult and analyze. Its design is geared towards being a practical tool for researchers, media professionals, ordinary citizens, businesses managers, and society at large, given its wide operational capacity.

TERAIN Help users can investigate the following types of questions:

- Is the environmental performance of a particular company increasing? Given its industrial activity and size, is this company the environmental champion it claims to be?
- How polluted is the water in a nearby river or lake?
- How safe is the air I breathe in my city?
- What is the (parent) company's action towards its emissions?

1.1 Background information on the E-PRTR and the TRI

Eight months after the chemical disaster in Union Carbide's Bhopal plant in December 1984, Union Carbide's West Virginia plant in the US went through another gas leak that triggered the enactment of measures of a diverse nature. The EPA's Emergency Planning and Community Right-to-Know Act of 1986 was both the first initiative among all taken, and the first among all legislative provisions. In this way, the EPCRA established the basis for TRI in section 313, before it was further elaborated through section 6607 of the Pollution Prevention Act (42 USC, 1986; 42 USC, 1990). The OECD and the UNECE followed the EPA's path soon after, setting international guidelines, disseminating knowledge, and raising awareness for the development of PRTRs (OECD 1996; UNECE 1998). Simultaneously the European Union walked its first steps towards the current E-PRTR with the European Pollutant Emission Register, implemented through the Commission Decision 2000/479.

According to the EPA's website, the TRI is a mandatory program that registers and publishes every year an annual report on a total of 794 chemicals in 33 categories that can cause "cancer or other chronic human health effects, significant adverse acute human health effects, and/or significant adverse environmental effects". These 770 chemicals can either be released and/or managed through recycling, energy recovery and treatment methods. The list of chemical substances covered by the TRI program has undergone several expansions throughout its history, and it is submitted to constant updates and revisions.

The TRI program sets three criteria that require facilities that meet all of them to submit an annual report before July 1st of the following year. These criteria are (1) to operate in any of the covered industry sectors, (2) to employ 10 or more full-time employees or their equivalent, and (3) to produce, process, and/or employ any of the TRI-listed chemicals in quantities that surpass the established thresholds. The 33 categories include a variety of metals, metalloids, persistent organic pollutants, polycyclic aromatic compounds, per- and polyfluoroalkyl substances, and nitrates among others. The complete list of chemicals, as well as the necessary information for reporting facilities is easily accessible on the GuideME[1] section of the TRI program.

Regarding the consultation and download of the data and the annual reports, the TRI program offers a variety of 18 possibilities, tailored to different necessities and expertise levels. These tools and data export formats are divided in five categories:

1. Data as reported by facilities
2. National reports and factsheets
3. Tools for most users
4. Data and tools for advanced/customized analysis
5. Topic focused data and tools

The data files that are of greatest use in CEP are the ones that show the data from the TRI reports that facilities submit each year, allowing to consult data at the level of facility, parent company and region. These files are in categories 1 and 5.

With a similar premise as the TRI and the original EPER, the E-PRTR aims to ensure public and transparent access to data regarding the release of any pollutants, and waste transfers. Now, the E-PRTR is broader than the TRI program in some aspects, as it covers the pollutant release to the air, the water, and the soil, as well as waste transfers, and the release of greenhouse gasses (GHG). Reports on waste transfers, although contemplated, are not usual in the TRI, while GHGs are not included[2] These transfers can originate both from the main operating point of a facility, or from other occasional and/or diffused sources according to Regulation (EC) No 166/2006 (pp. 33/3-33/4)[3]. In this document, we use the terms 'facility' and 'diffuse sources as defined on article 2, sections (3) and (12) of the EC Regulation that has just been cited:

> (3) 'facility' means one or more installations located on the same site operated by the same natural or legal person; [...]
>
> (12) 'diffuse sources' means the many smaller or scattered sources from which pollutants may be released to land, air or water, whose combined impact on those media may be significant and for which it is impractical to collect reports from each individual source;
>
> (Regulation (EC) No 166/2006, p. 33/3)

The information in the E-PRTR database contains the data of over 60 000 industrial sites from the year 2007 onwards, allowing for public and free data consultation and download. The Industrial Emissions Directive (IED) requires all EU Member States, as well as Iceland, Liechtenstein, Norway, Serbia, and Switzerland, to report data annually, which then are published with a two-year delay,

[1] Find the section at <https://guideme.epa.gov/ords/guideme_ext/f?p=guideme:chemical-list-basic-search>

[2] EPA's Greenhouse Gas Reporting Program has been active since Title 40 of the Code of the Federal Regulations enacted its creation in 2010. However, the focus here is the TRI program as it is the most significant mandatory environmental reporting in the US given its scope and longevity.

[3] Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 on the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC.

through the EU Registry on Industrial Sites (EU Registry), and the E-PRTR on the European Industrial Emissions Portal[4]. This portal has been operating since 2021. As per the effects of Brexit, data for the UK is only available up to the year 2020.

This information on the E-PRTR encompasses a total of 65 economic activities across Europe, and the data for 91 pollutants. Regulation (EC) No 166/2006 defines *pollutants* as "any substance or group of substances which may be harmful to the environment or to human health by reason of their properties and their introduction into the environment" (p. 33/3). The list of pollutants, and their details, can be found in a glossary at the European Industrial Emissions Portal. The 91 pollutants belong to any of the following seven categories:

(1) Greenhouse gasses
(2) Other gasses
(3) Heavy metals
(4) Pesticides
(5) Chlorinated organic substances
(6) Other organic substances
(7) Inorganic substances

In addition, there are other aspects that European facilities must declare in their reports. The facility operator is tasked with elaborating the reports of the emissions to the air, water, and land. And in their report, they must include information on control data; emission factors; internationally recognized technical assessments; and methodology, which includes methods of calculation, measurement, and estimation. Similarly, the operator must also include data of transferred hazardous waste, and any other pollutants emitted from the activities performed at the facility. These data also differentiate whether the transfer and release of these pollutants has been either deliberate, or accidental, and habitual, or occasional.

Not all European facilities are required to submit the described information to the E-PRTR. Only those facilities that meet one of the following criteria must do so:

a) Belong to at least one of the contemplated 65 economic activities out of the following nine categories: energy sector, production and processing of metals, mineral industry, chemical industry, waste and wastewater management, paper and wood production and processing, intensive livestock and aquaculture, animal and vegetable products from the food and beverage sector, and other activities.
b) Exceed at least one of the E-PRTR capacity thresholds.
c) Exceed the thresholds for the release of air, water, and/or land pollutants specified in Annex II of the Regulation. This annex defines the applicable thresholds.

Therefore, the E-PRTR contains data on: (a) pollutant emissions and activities on emissions to land, air, or water; (b) off-site transfers of hazardous or non-hazardous wastes; (c) off-site transfers of any pollutants in wastewater; (d) emissions from diffuse sources that are likely to have a significant impact on the air, water, or land. It is worth noting that the database gives access to the information through several categories and data analysis tools. Those, as well as the functions of data visualization and download can be found on the European Industrial Emissions Portal for free. Regarding the format, data are presented in both aggregated and non-aggregated form. Thus, users can find information sorted out by:

a) Facility, including the facility's parent company

[4] European Industrial Emissions Portal. Pollutant index: https://industry.eea.europa.eu/pollutants/pollutant-index

b) Geographic location via online map
c) Activity
d) Occurrence at Member State or Community level
e) Pollutant or residue
f) Medium (air, water, land) into which the pollutant is released
g) Off-site waste transfers and their destination
h) Off-site transfers of pollutants in wastewater
i) Diffuse sources
j) Installation Operator

With this said, there are a series of drawbacks in the configuration of the E-PRTR. Despite the public availability, obtaining cross-sectional or longitudinal data from a company can be complicated. Especially if we take into account that the data must be consulted by selecting the pollutants individually.

Moreover, there are missing data on the E-PRTR. This happens due to the thresholds establishing that the reports of release and transfers are only mandatory when they are exceeded. In other words, if there are missing data for the releases and/or transfers in a given year, or in an economic activity in the E-PRTR, the corresponding threshold has not been met. And thus, there was no legal obligation for filing the appropriate report.

These two aspects can be seen as considerable drawbacks for anyone interested in working with reliable data sources regarding environmental performance and sustainability. And as such, they constitute two of the main motivations behind this research initiative.

1.2 Organization of this document

The following sections explain the methodology (data, variables, calculation, etc.) used to evaluate CEP of European companies. First, section 2 presents an overview of TERAIN Europe, highlighting the main differences with other environmental reporting databases. Second, section 3 details the raw data used to create the TERAIN dashboard of European companies. Section 4 then details the way that we assess the potential harms to human health and the environment depending on the nature of the pollutants. For this purpose, we refer to a series of toxicity weighting factors, explaining how they are established and applied. And finally, section 5 underlines the scores and indexes of TERAIN, as a consultation guide.

2 Overview of TERAIN Europe

2.1 Overview

TERAIN is a smart environmental dashboard that assesses the potential impact of the polluting industrial activities that generate the chemicals listed in the European Pollutant Release and Transfer Register (E-PRTR). Although based on data from the E-PRTR, TERAIN Europe is a powerful tool that is easy to use and understand.

The TRI and the E-PRTR are both comprehensive databases, as well as records of the polluting chemical substances emitted by any of the facilities they comprise, which can also be categorized by industry sector, and by region. However, the availability of the data is constrained by the established

thresholds, so it can be difficult to obtain data on a regular and continuous basis. Therefore, performing cluster analysis or comparisons over time is not an easily feasible option.

TERAIN Europe, on the other hand, poses as an easy, simple, and intuitive alternative. It assesses the release of pollutants at three different scales: facility, company, and region, using the official data recorded in the E-PRTR. In addition, it allows the user to select the analyzed time period; the pollutants that will be accounted for, weighted according to their toxicity in a single unit of measurement; and whether they want comparative data regarding the industrial activity, the evolution, or the volatility of the data. Thus, TERAIN enables an overall assessment of the pollution generated by each facility, company, or region that figures in the database without needing further manual processing or effort, other than just a few mouse clicks.

2.2 Strengths and limitations of TERAIN

Although both the E-PRTR and the TRI program provide public detailed data on the pollution of the most harmful chemicals emitted (or transferred) by facilities belonging to the most polluting industrial activities, they present a variety of drawbacks. Facilities only report their chemical emissions when they exceed certain levels. And on top of that, only raw data files can be downloaded. Any other level of aggregation or configuration has to be built *ad hoc* or manually, especially in the case of the European data.

TERAIN aims to address these problems. To do this, it sources the data out of the E-PRTR and the TRI, presenting it in a more intuitive and useful way for the user. It allows consultation at the already mentioned three different levels of aggregation: facility, company, and region. The data presented on TERAIN have already been weighted according to the toxicity of the chemical substances and are expressed in equivalence with the environmental damage caused by CO2 in each case. This enables enhanced levels of comparison and aggregation of the data, as well as a more holistic view of the levels of pollutant emissions that result from the calculation. In addition, it allows to obtain data from a specific point in time (for example in a specific year) or over a period of time, without issues derived from data aggregation or continuity.

Nevertheless, TERAIN is limited by the data constraints that follow the configuration of the data on these reporting tools: the number and scope of the pollutants, and the fact that only those facilities that meet the criteria for economic activity, and threshold surpassing are obligated to report. However, this raw data is more than enough to paint an accurate picture of the CEP caused by these facilities.

On the whole, the main advantage of TERAIN is offering an accessible and effortless way of measuring environmental impact data at the three (traditional) levels of aggregation (facility, company, and region) through a single assessment unit. Thus, TERAIN makes it possible to obtain a clear idea of the environmental impact through comparative data that generates longitudinal or temporal analysis, without the extra steps that are required when working with the raw data on PRTRs.

3 E-PRTR data used

This section contains information on the data used from E-PRTR, at three levels of disaggregation: the facility level, the company level, and the regional area level (NUTS, Nomenclature of Territorial Units for Statistics[5]).

The facility level provides information about a single facility, while the company level includes all of a company's facilities. The NUTS region level summarizes all facility data for the same NUTS region.

Each of the following tables (Tables 3.1-3.3) displays information about each level that contains: the name or the label of the data or variable that has been included in this database (item); location (file or source) where the item can be found; and a brief description of the item. There are four main locations or type of sources, each of which is detailed below:

a) **2_ProductionFacility**: contains the basic data for each facility that reports to the European Union (EU) Registry. This includes the name, location, and parent company details.
b) **2f_PollutantRelease** contains data on each pollutant released to the air, water, or land reported to the EU Registry on Industrial Sites and to either the E-PRTR or the Large Combustion Plants (LCP)[6] integrated reporting, which includes the type and quantity.
c) **2g_OffsitePollutantTransfer** contains data on each transfer of pollutants in wastewater reported to the EU Registry on Industrial Sites and the E-PRTR/LCP integrated reporting stream, including the type and quantity of waste. It also includes information about whether the waste was transferred within the country or out of it.
d) **2h_OffsiteWasteTransfer** contains data on waste transfers reported to the EU Registry on Industrial Sites and the E-PRTR/LCP integrated reporting stream, including the type and quantity of waste. It also includes information about whether the waste was transferred within the country or out of it.

A brief description of the item (data information): name of feature, reporting year, pollutant code, pollutant name, total pollutant quantity kilograms, accidental pollutant quantity kilograms, medium waste classification name, total waste quantity in tons, and its location at facility level, is depicted in table 3.1.

Table 3.1. Information at Facility level

Item	Location	Description
nameOfFeature	2_ProductionFacility	Name of the site.
reportingYear	2f_PollutantRelease 2g_OffsitePollutantTransfer 2h_OffsiteWasteTransfer	The calendar year of which data was gathered.
pollutantCode	2f_PollutantRelease 2g_OffsitePollutantTransfer	Pollutant code of the release. Each pollutant has an assigned code in the database.
pollutantName	2f_PollutantRelease 2g_OffsitePollutantTransfer	Pollutant name of the release.
totalPollutantQuantityKG	2f_PollutantRelease 2g_OffsitePollutantTransfer	Total quantity in kg released in the reporting year into the same medium for the pollutant referred to in the pollutant attribute.

[5] The NUTS regional code (Nomenclature of Territorial Units for Statistics) has been developed by the European Environment Agency (EEA).
[6] A new system that better integrates pollutant reporting under the E-PRTR and the Industrial Emissions Directive (IED) (More information on the European Commission's website: https://ec.europa.eu/environment/industry/stationary/e-prtr/implementation.htm)

accidentalPollutantQuantityKG,	2f_PollutantRelease	Total quantity in kg released accidentally in the reporting year into the same medium for the pollutant referred to in the pollutant attribute.
medium	2f_PollutantRelease	Medium (air, water) to which the pollutant is released.
wasteClassificationName	2h_OffsiteWasteTransfer	Name classifying the transfer according to whether it is hazardous or non-hazardous in nature.
totalWasteQuantityTNE	2h_OffsiteWasteTransfer	The quantity of the waste transfer in metric tons.

Source: Adapted Industrial reporting under the Industrial Emission Directive 2010/75/EU and European Pollutant Release and Transfer Register Regulation (EC) No 166/2006

Table 3.2 includes information about each item, its location, and a short description at the company level.

Table 3.2. Information at Company level

Item	Location	Description
parentCompanyName	2_ProductionFacility	Parent company name. The one that owns (total or partially) the subsidiary.
reportingYear	2f_PollutantRelease 2g_OffsitePollutantTransfer 2h_OffsiteWasteTransfer	The calendar year of which data was gathered.
pollutantCode,	2f_PollutantRelease 2g_OffsitePollutantTransfer	Pollutant code of the release. Each pollutant has an assigned code in the database.
pollutantName	2f_PollutantRelease 2g_OffsitePollutantTransfer	Pollutant name of the release.
totalPollutantQuantityKG	2f_PollutantRelease 2g_OffsitePollutantTransfer	Total quantity in kg released in the reporting year into the same medium for the pollutant referred to in the pollutant attribute.
accidentalPollutantQuantityKG	2f_PollutantRelease	Total quantity in kg released accidentally in the reporting year into the same medium for the pollutant referred to in the pollutant attribute.
medium	2f_PollutantRelease	Medium (air, water) to which the pollutant is released.
wasteClassificationName	2h_OffsiteWasteTransfer	Name classifying the transfer according to whether it is hazardous or non-hazardous in nature.
totalWasteQuantityTNE	2h_OffsiteWasteTransfer	The quantity of the waste transfer in metric tonnes.

Source: Adapted Industrial reporting under the Industrial Emission Directive 2010/75/EU and European Pollutant Release and Transfer Register Regulation (EC) No 166/2006

Finally, table 3.3 includes information about items, location, and a short description at regional NUTS level. There are three levels of NUTS:

- NUTS 1: major socio-economic regions
- NUTS 2: basic regions for the application of regional policies
- NUTS 3: small regions for specific diagnoses

Table 3.3. Information at NUTS level

Variable	Ubication	Description
NUTSRegionSourceCode	2_ProductionFacility	NUTS region code. Field mapped by the European Environment Agency (EEA) using facility coordinates. The NUTS (Nomenclature of territorial units for statistics) classification is a hierarchical system for dividing up the economic territory of the EU and the UK for different purposes. There are three levels of NUTS (NUTS-1, NUTS-2, and NUTS-3), each one covering a different level of areas.
reportingYear	2f_PollutantRelease 2g_OffsitePollutantTransfer 2h_OffsiteWasteTransfer	The calendar year of which data was gathered
pollutantCode	2f_PollutantRelease 2g_OffsitePollutantTransfer	Pollutant code of the release. Each pollutant has an assigned code in the database.
pollutantName	2f_PollutantRelease 2g_OffsitePollutantTransfer	Pollutant name of the release.
totalPollutantQuantityKG	2f_PollutantRelease 2g_OffsitePollutantTransfer	Total quantity in kg released in the reporting year into the same medium for the pollutant referred to in the pollutant attribute.
accidentalPollutantQuantityKG	2f_PollutantRelease	Total quantity in kg released accidentally in the reporting year into the same medium for the pollutant referred to in the pollutant attribute.
medium	2f_PollutantRelease	Medium (air, water) to which the pollutant is released.
wasteClassificationName	2h_OffsiteWasteTransfer	Name classifying the transfer according to whether it is hazardous or non-hazardous in nature.
totalWasteQuantityTNE	2h_OffsiteWasteTransfer	The quantity of the waste transfer in metric tonnes.

Source: Adapted Industrial reporting under the Industrial Emission Directive 2010/75/EU and European Pollutant Release and Transfer Register Regulation (EC) No 166/2006

4 Toxicity Weights

Not every pollutant has the same damaging effect on human health nor the environment. Starting from this premise, the toxicity of each of the listed chemical compounds is evaluated, to assign a toxicity weighting factor to each one. The toxicity weighting factor for each chemical compound derives from two different sources:

1) US Toxic Release Inventory (TRI) database
2) The Greenhouse Gas Protocol (Intergovernmental Panel on Climate Change (IPCC)). Working Group Report AR5 *Climate Change 2013: The Physical Science Basis*.

4.1 Toxicity based on US Toxic Release Inventory (TRI)

The US Toxic Release Inventory (TRI) database uses 19 indicators to calculate the toxicity of a total of 794 chemical compounds. Table 4.1 shows the definition of each abbreviation used and how each of the TRI toxicity indicators are calculated:

Table 4.1. Toxicity Indicators used in TRI database

Abbreviation	Description
RfCInhale	Reference Concentration (mg/cu. M).
RfCUF	Uncertainty factor, modifying factor, and confidence level obtained from the RfC source, if available.
RfCConf	Reference Concentration (mg/cu. M).
RfCToxWeight	Calculation of toxicity weight from RfC.
RFDOral	Reference Dose (mg/kg-day).
RfDUF	Uncertainty factor, modifying factor, and confidence level obtained from the RfD source, if available.
RfDMF	Calculation of toxicity weight from RfC.
RfDToxWeight	Calculation of oral toxicity weight from RfD.
UnitRiskInhale	Inhalation Unit Risk (risk per mg/cu. M).
IURToxWeight	Calculation of inhalation toxicity weight from IUR.
QSTAROral	Oral Slope Factor (risk per mg/kg-day).
OSFToxWeight	Calculation of oral toxicity weight from OSF.
WOE	Cancer weight of evidence designation used in the calculation of toxicity weights from cancer toxicity metrics.
ITW	Final inhalation toxicity weight (Equation used to either select tox weight from oral pathway if no hidden inhalation tox score is available or select the inhalation tox weight and adjust the significant figures displayed).
ToxicityClassOral	Denotes if cancer or non-cancer data is used to generate final oral tox weight; asterisk denotes that the toxicity weight is adopted from the inhalation pathway.
ToxicityCategory	Indicates whether the oral and inhalation toxicity weights are based on cancer health effects, non-cancer health effects, or both.
MaxNc	**It shows NON-CANCER toxicity for each chemical compound. It is calculated as the greater non-cancer value between ODToxWeight and RfCToxWeight indicator.**
MaxC	**It shows for each chemical compound the CARCINOGENIC toxicity. It is calculated as the greater cancer value between OSFToxWeight and IURToxWeight indicators.**
MaxTW	**Shows the greater of the two possible toxicity weights (oral or inhalation).**

Once all these parameters are established, a matching criterion is applied between the degree of non-carcinogenic (MaxNC) and carcinogenic (MaxC) toxicity for the 643 chemical compounds that are included in the. TRI and in the E-PRTR. For this purpose, greater value between MaxNc and MaxC indicators for each E-PRTR chemical compound (MaxTW indicator) has been taken as the toxicity weighting factor.

In this step, a toxicity weighting factor could not be assigned to some E-PRTR chemical compounds since they did not appear in the TRI database. Table 4.2 shows the toxicity weighting factor for the chemical compounds in the E-PRTR according to information on the TRI database.

Table 4.2. Toxicity weighting factor for the chemical compounds included in E-PRTR based on TRI database information.

E-PRTR chemical compounds	Toxicity weighting factor
1,1,1-trichloroethane	0.7
1,1,2,2-tetrachloroethane	210000
1,2,3,4,5,6-hexachlorocyclohexane (HCH)	6400000
1,2-dichloroethane (DCE)	93000
Alachlor	80000
Aldrin	18000000
Ammonia (NH3)	7
Anthracene	3.3
Arsenic and compounds (As)	15000000
Asbestos	170000000
Atrazine	56
Benzene	55000
Benzo(g, h, i)perylene	20000
Brominated diphenyl ethers (PBDE)	8900000
Cadmium and compounds (as Cd)	6400000
Chlordane	360000
Chlorine and inorganic compounds (as HCl)	23000
Chlorofluorocarbons (CFCs)	5
Chlorpyrifos	1000
Chromium and compounds (as Cr)	43000000
Copper and compounds (as Cu)	1500
Cyanides (as total CN)	4400
Di-(2-ethyl hexyl) phthalate (DEHP)	14000
Dichloromethane (DCM)	2000
Diuron	19000
Ethyl benzene	1100
Ethylene oxide	11000000
Fluorine and inorganic compounds (as HF)	17
Halons	0
Heptachlor	4600000
Hexachlorobenzene (HCB)	1600000
Hexachlorobutadiene (HCBD)	7900
Hydrogen cyanide (HCN)	4400
Isodrin	0
Lead and compounds (as Pb)	23000
Lindane	110000
Mercury and compounds (as Hg)	12000
Naphthalene	12000
Nickel and compounds (as Ni)	930000
Nonylphenol and Nonylphenol ethoxylates (NP/NPEs)	0
PCDD + PCDF (dioxins + furans) (as Teq)	1400000000
Pentachlorobenzene	1300
Pentachlorophenol (PCP)	400000
Phenols (as total C)	18
Polychlorinated biphenyls (PCBs)	2000000

E-PRTR chemical compounds	Toxicity weighting factor
Polycyclic aromatic hydrocarbons (PAHs)	390000
Simazine	12000
Tetrachloroethylene (PER)	2100
Tetrachloromethane (TCM)	70000
Toluene	13
Total nitrogen	0
Total phosphorus	50000
Toxaphene	1100000
Tributyltin and compounds	3300
Trichlorobenzene (TCBs) (all isomers)	100
Trichloroethylene	15000
Trichloromethane	82000
Trifluralin	770
Vinyl chloride	1500000
Xylenes	35
Zinc and compounds (as Zn)	100

4.2 Toxicity based on the Greenhouse Gas Protocol (Intergovernmental Panel on Climate Change (IPCC))

TERAIN uses the toxicity weighting factors provided by the Greenhouse Gas (GHG) Protocol too. The Greenhouse Gas Protocol establishes comprehensive global standardized frameworks to measure and manage greenhouse gas emissions (GHGE) derived from operation at both the private and the public sector, value chains, and mitigation actions.

The GHG Protocol supplies the world's most widely used GHG accounting standards. Particularly for corporations, the Corporate Accounting and Reporting Standard[7] compiles requirements, guidance, and an accounting platform for virtually every corporate GHG reporting program in the world. It covers the accounting and reporting of the seven greenhouse gasses covered under the Kyoto Protocol – carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PCFs), sulfur hexafluoride (SF6) and nitrogen trifluoride (NF3). The GHG Protocol Corporate Accounting and Reporting Standard was updated in 2015 with the addition of the Scope 2 Guidance. This provided companies with further instructions on how to measure and report with credibility the emissions derived from purchased or acquired electricity, steam, heat, and cooling systems.

In order to provide data based on a one-unit system of measurement, TERAIN converts all GHG emissions to CO2 equivalents (CO2-eq) according to the EPA's "Greenhouse Gas Equivalencies Calculator."[8] This calculator is a useful tool for the elaboration of greenhouse-gas reduction strategies, reduction targets, or other initiatives aimed at reducing GHG emissions.

The conversion of GHG to CO2-eq has been done according to the Intergovernmental Panel on Climate Change (IPCC), "Climate Change 2013: IPCC Fifth Assessment Report (AR5)"

[7] See the website https://ghgprotocol.org/corporate-standard for more details.

[8] This tool can be consulted at https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

(https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf; https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-ts-1.pdf).

Table 4.3 shows the toxicity weighting factors provided by the Greenhouse Gas Protocol based on CO2 conversion. We can observe for each E-PRTR chemical compound its corresponding conversion.

Table 4.3. Toxicity weighting factor provided by Greenhouse Gas Protocol based on CO2 conversion

	GREENHOUSE GAS EMISSIONS (GHGE)	Toxicity weighting factor based on CO2 CONVERSION
Carbon dioxide (CO2)	GHGE	1
Hydrofluorocarbons (HFCs)	GHGE	2208
Methane (CH4)	GHGE	28
Nitrous oxide (N2O)	GHGE	265
Perfluorocarbons (PFCs)	GHGE	8628
Sulfur hexafluoride (SF6)	GHGE	23500

Unfortunately, the E-PRTR does not provide disaggregated information of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) into sub-chemical compounds. Therefore, and aiming to obtain CO2-eq for HFCs and PFCs at global levels, an arithmetic sum of the CO2-eq values for each sub-chemical compound under HFCs and PFCs has been carried out.

Table 4.4a. y 4.4b. shows the CO2-eq conversion for each sub-chemical compound under HFCs and PFCs, and the arithmetic mean for each of the two groups (see last row for HFCs and PFCs).

Table 4.4a CO2 conversion for each sub-chemical that belongs to HFCs

Hydrofluorocarbons (HFCs)		
Name	**Formula**	**CO2 EQUIVALENT**
trifluoromethane	CHF3	12400
difluoromethane	CH2F2	677
fluoromethane	CH3F	116
pentafluoroethane	C2HF5	3170
1,1,2,2-tetrafluoroethane	C2H2F4	1120
1,1,1,2-tetrafluoroethane	C2H2F4	1300
1,1,2-trifluoroethane	C2H3F3	328
1,1,1-trifluoroethane	C2H3F3	4800
1,2-difluoroethane	C2H4F2	16
1,1-difluoroethane	C2H4F2	138
fluoroethane	C2H5F	4
1,1,1,2,3,3,3-heptafluoropropane	C3HF7	3350
1,1,1,2,2,3-hexafluoropropane	C3H2F6	1120
1,1,1,2,3,3-hexafluoropropane	C3H2F6	1330
1,1,1,3,3,3-hexafluoropropane	C3H2F6	8060
1,1,2,2,3-pentafluoropropane	C3H3F5	716
1,1,1,3,3-pentafluoropropane	C3H3F5	858
1,1,1,3,3-pentafluorobutane	C4H5F5	804
1,1,1,2,3,4,4,5,5,5-decafluoropentane	C5H2F10	1650
ARITHMETIC MEAN		**2208**

Table 4.4b: CO2 conversion for each sub-chemical that belongs to PFCs

Perfluorocarbons (PFCs)		
Name	**Formula**	**CO2 EQUIVALENT**
PFC-14 (perfluoromethane)	CF4	6630
PFC-116 (perfluoroethane)	C2F6	11100
PFC-218 (perfluoropropane)	C3F8	8900
PFC-318 (perfluorocyclobutane)	c-C4F8	9540
PFC-3-1-10 (perfluorobutane)	C4F10	9200
PFC-4-1-12 (perfluoropentane)	C5F12	8550
PFC-5-1-14 (perfluorohexane)	C6F14	7910
PFC-9-1-18 (perfluorodecalin)	C10F18	7190
ARITHMETIC MEAN		**8628**

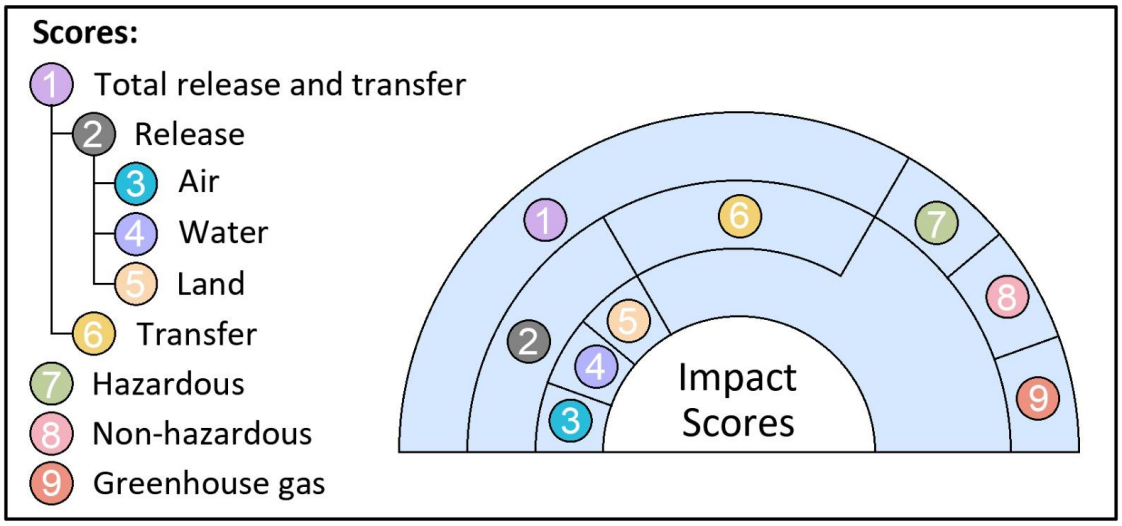
5 Scores and indexes of TERAIN

The data at TERAIN are divided into scores and indexes based on PRTR data that has been enhanced through the design of proprietary analytical methodology. This has resulted in the presentation of this data in a more sophisticated form that allows to conduct more complex and elaborated studies.

TERAIN's scores a total of 9 indicators that aim to capture the real environmental impact at the facility, company, and region levels. In order to do that, TERAIN considers two types of toxicity factors: (1) Toxicity based on the US Toxic Release Inventory (TRI), and (2) Toxicity based on the Greenhouse Gas Protocol (Intergovernmental Panel on Climate Change (IPCC)). In this way the features at TERAIN surpass the E-PRTR and allow for more precise and updated evaluation of a pollutant's toxicity. The scores (see figure 1), as they appear in TERAIN, are:

1. Total Release and Transfer (score 1)
    1.1. Release (score 2)
        1.1.1. Air Release (score 3)
        1.1.2. Water Release (score 4)
        1.1.3. Land Release (score 5)
    1.2. Transfer (score 6)
2. Transfer Hazardous Waste (score 7)
3. Transfer Non-Hazardous Waste (score 8)
4. Greenhouse Gas Emission (CO2 eq) (score 9)

Figure 5.1. Impact score



These scores are an aggregation of the toxicity weighting factors of each of the reported pollutants. Each of them reflects either the medium or the process involved in the reported emissions at any of the three levels of aggregation (facility, company, or region). Table 5.1 summarizes below these nine indicators in a way that applies to the three of them.

In addition, TERAIN uses these nine EPIs to generate up to seven comparative Environmental Risk Indexes that situate the scores of every search item in their corresponding percentile. These ERIs rank every facility, company, and region according to the result of their yearly scores, based on cluster analysis methods. The tables 5.2, 5.3, and 5.4 below are a summary of what each of these ERIs are like, according to the aggregation level. The goal of these ERIs is to provide users with descriptive statistics regarding CEP. In this way, both stakeholders and ordinary users without specialized knowledge can be better informed in their decision-making processes, while researchers and experts save time and resources on data-processing, focusing on performing more complex analyses.

5.1 Facilities' scores and indexes

The facilities' scores are obtained from an average weighted sum carried out at facility level. To do that the value of each chemical compound is multiplied by its respective toxicity factor, based on the TRI or the Greenhouse Gas Protocol of IPPC as it was stated above. This toxicity factor includes both carcinogenic and non-carcinogenic compounds.

The aggregation process at facility level is made as follows:

1. The reported amount of the chemical compound stated in the E-PRTR database is multiplied by its specific toxicity weighting factors according to both the TRI and the GHG Protocol of IPPC.
2. This produces two different columns: one in which each row shows the product of the weighting factor based on TRI, and another one showing the product of the weighting factor based on Greenhouse Gas Protocol (CO2-eq).
3. The sum between the values of these 2 columns produces as a result the global environmental impact for each of the 9 scores.
4. In order to generate the appropriate values for each of the environmental impact scores (see figure 1), the chemical compounds are aggregated depending on:
    - if they were released, the medium they were released into (air, water, or land which is scores 3, 4, and 5 respectively)

- if they were transferred from a certain facility to another one in a different location (off-site facility) for any reason as reported to an official PRTR, (total of transferred substances, score 6)

5. The “Release” (score 2) reflected as a total of released substances, and “Total Release and Transfer” (score 1) reflected total released and transferred substances.
6. The "Transfer Hazardous Waste" (score 7) is an estimate based on the quantity of hazardous waste from a certain facility that is transferred to another one in a different location (off-site facility), as reported to an official PRTR and The "Transfer Non-Hazardous Waste" (score 8) is an estimate based on the quantity of non-hazardous waste from a certain facility that is transferred to another one in a different location (off-site facility), as reported to an official PRTR.
7. The "Greenhouse Gas Emissions" (score 9) is an estimate based on the emissions of carbon dioxide equivalents (CO2-eq) from a specific facility, as reported to an official PRTR.

If the facility consists of several plants, the scores require prior aggregation by "nameOfFeature" which appears at the "2_ProductionFacility" table. Likewise, the scores will be grouped by years, considering the common field "reportingYear" (tables "2f_PollutantRelease", "2g_OffsitePollutantTransfer" and "2h_OffsiteWasteTransfer"). Taking all of the above into account, the facilities get assigned a value for the applicable scores. This can be better understood if we take as an example what would happen with the data of a facility that only reports pollutant releases to the air, and transfer of hazardous and non-hazardous waste. In such a case, TERAIN would produce indexes only with those three scores, as well as the CO2-eq emissions one, since the release of pollutants to the air would most certainly include greenhouse gasses.

Now, for this to happen, the aggregation process first produces the corresponding values for a facility in each of the nine scores. This is done based on the data extracted from the corresponding PRTR, as explained in previous paragraphs. These values, calculated for each of the years and scores with the available data, are then transformed into percentiles for the indexes to work with. In this case, there are a total of six ERIs that help evaluate a facility’s environmental performance in comparison with its competitors. The ERIs divide into three categories depending on the variable that the comparison reflects: industrial activity, improvement over time, or data predictability. Table 5.2 covers all six ERIs as they are shown in the dashboard.

The first one, *Activity Comparison: Ranking*, produces two ERIs, FER-Activity, and FER-Activity & Region, where the independent variables are the industrial activity in one, and the industrial activity per location in the other. This means that while the first focuses only on economic activity across the whole database either for Europe or the US (F1), the second one is the product of a two-factor analysis where F2 is the specific NUTS 3 statistical region.

The second one, *Time Comparison: Improvement* produces three ERIs following a similar pattern. The independent variable here is the temporal evolution of the selected facility’s scores. Thus, in the FEI we first obtain the variance percentage among each year and the three immediately preceding ones (F1). Then, the FAEI index adds economic activity (F2), while the FBEI index shows the evolution of the regional competitors since F3 here is the NUTS 3 statistical region.

The third and last one, *Predictive Comparison: Volatility* produces just one ERI, the FPE. This ERI uses a time series analysis to create a predictive model of what could be the raw value of the selected EPIs for the latest year with available data, and then compares it to the actual value.

5.2 Companies' scores and indexes

The company's scores are an aggregation of each pollutant's amount by company. It is calculated by using the variable or item "parentCompanyName'' in the "2_ProductionFacility" table. They are also grouped by years, considering the common field "reportingYear" (tables "2f_PollutantRelease", "2g_OffsitePollutantTransfer'' and "2h_OffsiteWasteTransfer"). Once the amounts of pollutants are aggregated at the company level, they are weighted by their toxicity factor and added in the same above mentioned procedure. Regarding the ERIs, the ones reflecting the comparison by economic activity, and data predictability, mirror the Indexes for the facility level. The difference appears when selecting *Time Comparison: Improvement* on the dashboard. For instance, there are four ERIs instead of three, and their functioning is slightly different. Table 5.3 covers all ERIs as they are shown in the dashboard.

5.3 Regions' scores and indexes

The regions' scores are an aggregation of each pollutant's amount per region. It is calculated by using the variable or item "NUTSRegionSourceCode" in the "2_ProductionFacility" table. These are also grouped by years, considering the common item "reportingYear" (tables "2f_PollutantRelease", "2g_OffsitePollutantTransfer" and "2h_OffsiteWasteTransfer"). Once the amounts of each pollutant are aggregated at region level, they are weighted by their toxicity factor and added following the same procedure as the scores for the other two levels. Table 5.4 covers all ERIs as they are shown in the dashboard.

Table 5.1 Scores for all three levels

SCORE	DESCRIPTION	HOW TO UNDERSTAND IT	METRICS
TOTAL RELEASE AND TRANSFER SCORE	The "Total Release and Transfer Score" is an estimate based on environmental records concerning the quantity and the toxicity of all the main toxic chemicals that a facility releases into the air, the water and the land. It also takes into account the quantity and toxicity of the chemicals that are transferred to other off-site facilities. We extract the data on the quantity of these chemicals from official PRTRs. Meanwhile, we assess their toxicity considering the international standards of impact equivalence.	The "Total Release and Transfer Score" is a unitless number that reflects the amount of chemical substances that a facility, company or region releases and transfer, as well as their toxicity. This score is especially useful when compared to other "Total Release and Transfer Scores" through our indexes (e.g. when comparing with the same reporting unit historically, similar units in the company, similar reporting units in competitors, or the industry average). The higher the score, the higher the relative potential for environmental risks. Bear in mind, a high "Total Release and Transfer Score" does not necessarily imply a high-level risk. This is because the final value of this score depends on the aggregation level of the scores, the amount of generated emissions, and the field of industrial activity. However, and as reflected in our indexes, variations of this score may be useful to identify situations of potential concern.	"Total Release and Transfer Score" is an aggregate of the "Release Score" and "Transfer Sore" in our metrics.
RELEASE SCORE	The "Release Score" is an estimate based on environmental records regarding the quantity and the toxicity of all the main toxic chemicals that a specific facility releases into the air, the water and the land (as reported to an official PRTR database according to international standards).	The "Release Score" is a unitless number that reflects the amount of chemical substances that a facility, company or region releases, as well as their toxicity. This score is especially useful when compared to other "Release Scores" through our indexes (e.g. when comparing with the same reporting unit historically, similar units in the company, similar reporting units in competitors, or the industry average). The higher the score, the higher the relative potential for environmental risks. Bear in mind, a high "Release Score" does not necessarily imply a high-level risk. This is because the value of this score depends on the aggregation level of the scores of Air, Water and Land release, the amount of released substances, and the field of industrial activity. However, and as reflected in our indexes, variations of this score may be useful to identify situations of potential concern.	The "Release Score" is an aggregate of the "Air Release Score", the "Water Release Score", and the "Land Release Score" in our metrics.

SCORE	DESCRIPTION	HOW TO UNDERSTAND IT	METRICS
AIR RELEASE SCORE	The "AirRelease Score" is an estimate based on environmental records regarding the quantity and the toxicity of all the main toxic chemicals that a specific facility releases into the air (as reported to an official PRTR database according to international standards).	The "Air Release Score" is a unitless number that reflects the amount of chemical releases and their toxicity as reported to the concerned PRTR. This score is only useful when compared to other scores of the same kind through our indexes. The higher the score, the higher the relative potential for environmental risk. Bear in mind that this score does not reflect the level of risk (e.g. correlation with cancer prevalence), and should not be used solely to draw conclusions on that matter. This is because the objective of this score is to identify situations of potential concern. Additional research should be always performed before drawing any conclusions regarding the level of risks.	The "Air Release Score" is an aggregate of the environmental impacts caused by the toxic chemicals that enter the air. For this purpose, these substances are weighted by levels of toxicity.
WATER RELEASE SCORE	The "Water Release Score" is an estimate based on environmental records regarding the quantity and the toxicity of all the main toxic chemicals that a specific facility releases into the water (as reported to an official PRTR database according to international standards).	The "Water Release Score" is a unitless number that reflects the amount of chemical releases and their toxicity as reported to the concerned PRTR. This score is only useful when compared to other scores of the same kind through our indexes. The higher the score, the higher the relative potential for environmental risk. Bear in mind that this score does not reflect the level of risk (e.g. correlation with cancer prevalence), and should not be used solely to draw conclusions on that matter. This is because the objective of this score is to identify situations of potential concern. Additional research should be always performed before drawing any conclusions regarding the level of risks.	The "Water Release Score" is an aggregate of the environmental impacts caused by the toxic chemicals that enter the water. For this purpose, these substances are weighted by levels of toxicity.
LAND RELEASE SCORE	The "Land Release Score" is an estimate based on environmental records regarding the quantity and the toxicity of all the main toxic chemicals that a specific facility releases into the land (as reported to an official PRTR database according to international standards).	The "Land Release Score" is a unitless number that reflects the amount of chemical releases and their toxicity as reported to the concerned PRTR. This score is only useful when compared to other scores of the same kind through our indexes. The higher the score, the higher the relative potential for environmental risk. Bear in mind that this score does not reflect the level of risk (e.g. correlation with cancer prevalence), and should not be used solely to draw conclusions on that matter. This is because the objective of this score is to identify situations of potential concern. Additional research should be always performed before drawing any conclusions regarding the level of risks.	The "Land Release Score" is an aggregate of the environmental impacts caused by the toxic chemicals that enter the land. For this purpose, these substances are weighted by levels of toxicity.

SCORE	DESCRIPTION	HOW TO UNDERSTAND IT	METRICS
TRANSFER SCORE	The "Transfer Score" is an estimate based on environmental records regarding the quantity and the toxicity of the chemicals that are transferred from a certain location to another one in a different location (e.g. off-site facility) for any reason (e.g. energy recovery; waste recycling, treatment, or disposal) as reported to an official PRTR. The creation of landfills, surface impoundments, and underground injections at a receiving facility are taken into account as well.	The "Transfer Score" is a unitless number that reflects the amount of chemical substances that a facility, company and region transfed in a different location, as well as their toxicity. This score is specially useful when compared to other "Transfer Scores" through our indexes (e.g. when comparing with the same reporting unit historically, similar units in the company, similar reporting units in competitors, or the industry average). The higher the score, the higher the relative potential for environmental risks. Bear in mind, a high "Transfer Score" does not necessarily imply a high-level risk. This is because the final value of this score depends on the aggregation level of the scores, the amount of generated emissions, and the field of industrial activity. However, and as reflected in our indexes, variations of this score may be useful to identify situations of potential concern.	The "Transfer Score" is an aggregate of the environmental impact that the transferring of toxic substances to an off-site facility causes. For this purpose, these substances are weighted by levels of toxicity.
TRANSFER HAZARDOUS WASTE	The "Transfer Hazardous Waste" score is an estimate based on the quantity of hazardous waste that is transferred to another one in a different location (e.g. off-site facility), as reported to an official PRTR.	The "Transfer Hazardous Waste" score is an aggregate of the amount of hazardous waste transferred to another one in a different location (e.g. off-site facility), as reported to an official PRTR. The higher the score, the higher the relative potential for environmental risk. Bear in mind that this score does not reflect the level of risk (e.g. correlation with cancer prevalence), and should not be used solely to draw conclusions on that matter. This is because the objective of this score is to identify situations of potential concern. Additional research should be always performed before drawing any conclusions regarding the level of risks.	Transfer Hazardous waste is measured in tones.
TRANSFER NON-HAZARDOUS WASTE	The "Transfer Non-Hazardous Waste" score is an estimate based on the quantity of non-hazardous waste that is transferred to another one in a different location (e.g. off-site facility), as reported to an official PRTR.	The "Transfer Non-Hazardous Waste" score is an aggregate of the amount of non-hazardous waste transferred to another one in a different location (e.g. off-site facility), as reported to an official PRTR. The higher the score, the higher the relative potential for environmental risk. Bear in mind that this score does not reflect the level of risk (e.g. correlation with cancer prevalence), and should not be used solely to draw conclusions on that matter. This is because the objective of this score is to identify situations of potential concern. Additional research should be always performed before drawing any conclusions regarding the level of risks.	Transfer Hazardous waste is measured in tones.
GREENHOUSE GAS EMISSIONS (CO2-eq)	The "Greenhouse Gas Emissions" score is an estimate based on the emissions of carbon dioxide equivalents (CO2-eq) as reported to an official PRTR.	The "Greenhouse Gas Emissions" score is measured in CO2-eq. The CO2-eq is a measuring unit used to compare the emissions of various greenhouse gasses on the basis of their global-warming potential (GWP). This is done by converting the values of the registered amount of other gasses to the equivalent amount of CO2.	The "Greenhouse Gas Emissions" is an aggregate of the greenhouse gas emissions. For this purpose, the values for the emissions of these gasses are converted to CO2-eq.

Table 5.2. Indexes for Facility levels

INDEX	DEFINITION	HOW TO UNDERSTAND IT	METRICS
FACILITY ENVIRONMENTAL IMPACT RANKING - ACTIVITY	The "FER-Activity" index measures the environmental impact of the analyzed facility depending on its main industrial activity (eg. a 60 means that the environmental impact of the analyzed facility is higher than that of 60% of its competitors).	The "FER-Activity" index ranks a facility's environmental risks by comparing it with others in the same field of industrial activity. Facilities with higher environmental risks have higher values in the index (e.g. an 80 means that the environmental impact score of the analyzed facility is higher than that of 80% of facilities in the same field). This index acquires an added value if you use it for comparing the historical ranking within the facility, or comparing different facilities in the same company. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the final score of a facility (e.g. their volume of operations). However, a facility with a high score deserves close attention because it has a higher environmental impact than its competitors.	The "FER-Activity" index is a number that ranges from 0 to 100. It reflects the percentage of facilities with the same industrial activity that have a lower environmental impact score.
FACILITY ENVIRONMENTAL IMPACT RANKING - ACTIVITY & REGION	The "FER-Activity & Region" index measures the environmental risks of the analyzed facility depending on its main industrial activity and region. (eg. a 60 means that the environmental impact of the analyzed facility is higher than that of 60% of its competitors in the same region).	The "FER-Activity & Region" index ranks a facility's environmental risks by comparing it with others in the region that are in the same field of industrial activity. Facilities with higher environmental risks have higher values in the index (e.g. an 80 means that the environmental impact score of the analyzed facility is higher than that of 80% of facilities in the same field). This index acquires an additional value if you use it for comparing the historical ranking within the facility, or comparing different facilities of the same company. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the final score of a facility (e.g. their volume of operations). However, a facility with a high score deserves close attention because it has a higher environmental impact than its competitors.	The "FER-Activity & Region" index is a number that ranges from 0 to 100. It reflects the percentage of facilities with the same industrial activity, and in the same region, that have a lower environmental impact score.

INDEX	DEFINITION	HOW TO UNDERSTAND IT	METRICS
FACILITY ENVIRONMENTAL IMPACT IMPROVEMENT	The "FEI" index reflects in percentages the amount of variation in the environmental impact score of a facility. An increase in this percentage would mean that the environmental impact has increased too.	The "FEI" index assesses the evolution of the environmental risks of a facility. The lower the value, the lower the environmental risks (eg. a +20 would mean that the environmental impact of the facility is 20% higher than the average impact in the three past years; while a -15 would mean that the environmental impact score has decreased 15% in that time frame). This index acquires an additional value if you use it for comparisons with other facilities, among other possibilities. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the evolution (e.g. reinforced volume of operations). However, a facility with a high "FEI" score deserves close attention because of its increasing environmental risks.	The numbers in the "FEI" index are either positive or negative and reflect the percentage of variation in the environmental impact score for the analyzed facility. This index compares the current score with the average score of the same facility in the three previous years.
FACILITY-ACTIVITY ENVIRONMENTAL IMPACT IMPROVEMENT	The "FAEI" index reflects in percentages the average percentage of change on the environmental impact score for all the facilities in our database that pertain to the same industrial activity. An increase in this percentage would mean that the environmental impact has increased too.	The "FAEI" index assesses the evolution of the environmental risks of the facilities in the same industrial activity. The lower the value, the lower the environmental risks (eg. a +20 would mean that the environmental impact of the field, this current year, is 20% higher than the average impact in the three past years; while a -15 would mean that the environmental impact score has decreased 15% in that time frame). This index acquires an added value if you use it for comparing different fields. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the evolution (e.g. reinforced volume of operations). However, a field with a high "FAEI" score deserves close attention because of its increasing environmental risks.	The numbers in the "FAEI" index are either positive or negative and reflect the percentage of variation in the environmental impact score for all facilities in the same field of industrial activity. This index compares the current score with the average score of the same facility in the three previous years.

INDEX	DEFINITION	HOW TO UNDERSTAND IT	METRICS
FACILITY BENCHMARKING OF ENVIRONMENTAL IMPACT IMPROVEMENT	The "FBEI" is the difference between the "Facility Environmental Impact Improvement (FEI)" and the "Facility-Activity Environmental Impact Improvement" (FAEI)	The "FBEI" index assesses the evolution of the environmental risks in a facility by comparing it with the rest of the facilities in our database that are part of the same field of industrial activity. The lower the value, the greater the reduction in environmental risks compared to its competitors (eg. a -20 would mean that, this year, the facility has reduced their environmental impact score 20% more than the average facility in the same field). This index acquires an added value if you use it for comparing different fields. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the evolution (e.g. reinforced volume of operations). However, a facility with a high "FBEI" score deserves close attention because of poses higher environmental risks than its competitors.	The numbers in the "FBEI" **index** are either positive or negative and reflect the difference between two values: the percentage of variation in the environmental impact score for the analyzed facility; and the percentage of the average variation for the industry regarding the same score.
FACILITY PREDICTABILITY OF ENVIRONMENTAL IMPACT	The "FPE" index is the relative difference between two values: the facility's actual environmental impact score and the predicted score for the same year.	The "FPE" index assesses the volatility of the environmental risks in a facility. This index is a proxy of what continue to be unpredictable changes regarding the environmental risks of a facility. The "FPEI" index also can be used to measure whether the facility's environmental impact was higher or lower than expected when compared to a similar facility.	The numbers in the "FPE" index are either positive or negative and reflect the relative difference between two values: the facility's actual environmental impact score and the predicted score for the same year. The predicted score results from panel data that includes the environmental impact scores for all the facilities in our database and the control variables of activity, country, and year.

Table 5.3. Indexes for Company levels

INDEX	DEFINITION	HOW TO UNDERSTAND IT	METRICS
COMPANY ENVIRONMENTAL IMPACT RANKING-TOTAL	The "CER-Total" index measures the environmental impact of the analyzed company comparing it with others in our database (eg. a 60 means that the environmental impact of the analyzed company is higher than that of 60% in our database).	The "CER-Total" index ranks the environmental risks of a company by comparing it with others. Companies with higher environmental risks have higher values in the index (e.g. an 80 means that the environmental impact score of the analyzed company is higher than that of 80% of companies in the database). This index acquires an additional value if you use it for comparing the historical ranking within the company, or comparing different companies in the same industry. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the final score of a company (e.g. their volume of operations). However, a company with a high "CER-Total" score deserves close attention because it has a higher environmental impact than other companies.	The "CE(I)R-Total" index is a number that ranges from 0 to 100. It reflects the percentage of companies in our database that have a lower environmental impact score than the analyzed company.
COMPANY ENVIRONMENTAL IMPACT RANKING-ACTIVITY BENCHMARKING AVERAGE	The "CE(I)R-Average" index measures the environmental impact of the facilities in the company, comparing it to the average impact of facilities in the same industrial activity (eg. a 60 means that the environmental impact of the company's facilities is higher than that of 60% of its competitors).	The "CE(I)R-Average" index assesses the average environmental risks of the company's facilities and compares it to other facilities in the industry. The higher the value, the higher the environmental risks present in the company's facilities (e.g. an 80 means that the facilities in this company have a higher environmental impact than 80% of the facilities in our database that are in the same industry). This index acquires an additional value if you use it for comparing the historical ranking within the company, or comparing different companies in the same industry. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the final impact score of a facility (e.g. companies with operations in dirty industries will have a higher environmental impact than other companies with more environmentally friendly operations). However, a company with a high "CE(I)R-Average" score deserves close attention because it has a higher environmental impact than its competitors.	The "CE(I)R-Average" index is a number that ranges from 0 to 100. It reflects the percentage of facilities in our database that have a lower environmental impact score than those in the analyzed company.

INDEX	DEFINITION	HOW TO UNDERSTAND IT	METRICS
COMPANY ENVIRONMENTAL IMPACT IMPROVEMENT	The "CEI" index measures the percentage of average variation in the environmental impact score of all the facilities in a company.	The "CEI" index assesses the evolution of the environmental risks of a company. The lower the value, the lower the environmental risks (eg. a 20 would mean that the environmental impact of the facility is 20% higher than the average impact in the three past years; while a -15 would mean that the environmental impact score has decreased 15% in that time frame). This index acquires an additional value if you use it for comparing different companies. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the evolution (e.g. reinforced volume of operations). However, a facility with a high "CEI" score deserves close attention because of its increasing environmental risks.	The "CEI" index is either a positive or negative number that reflects the percentage of variation in the environmental impact score of the company's facilities. This index compares the current score with the average score of the facilities in the company from the three previous years (i.e. percentage of increase-decrease in the environmental score for the analyzed company).
COMPANY ACTIVITY ENVIRONMENTAL IMPACT IMPROVEMENT	The "CAEI" index measures the average percentage of change in the environmental impact score for all the industries in which the company operates (i.e. percentage of increase-decrease in the score for all the facilities in our database operating in the same industrial activities as the analyzed company).	The "CAEI" index assesses the average evolution of the environmental risks of the industrial field(s) in which the company operates. The lower the value, the lower the environmental risks (eg. a 20 would mean that, this year, the environmental impact of the field(s) is 20% higher than the average impact in the three past years; while a -15 would mean that the environmental impact score has decreased 15% in that time frame). This index acquires an additional value if you use it for comparing different companies. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence evolution. However, a company operating in a field with a high "CAEI" score deserves close attention because of its increasing environmental risks.	The "CAEI" index is either a positive or negative number that reflects the percentage of average variation in the environmental score for all the industrial activities in which the company operates (i.e. average percentage of increase-decrease).
COMPANY BENCHMARKING ENVIRONMENTAL IMPACT IMPROVEMENT	The “CBEI” is the difference between the “Company Environmental Impact Improvement”(CEI) and the “Company-Activity Environmental Impact Improvement” (CAEI)	The "CBEI" index assesses the evolution of the environmental risks of a company by comparing it to the average evolution in the field(s) in which the company operates. The lower the score, the lower the environmental risks that the company has in comparison with its competitors (e.g. a -20 would mean that the company reduced its environmental risks 20% more than its average competitors). This index acquires an additional value if you use it for comparing different companies. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the evolution (e.g. the company might have increased its volume of operations while its competitors have reduced it). In any case, a company with a high "CBEI" score deserves close attention because of its increasing environmental risks as opposed to its competitors.	The "CBEI" index is either a positive or negative number that reflects the difference in variation in the environmental impact score between the company's industrial activity (or activities) and the industry as a whole.

INDEX	DEFINITION	HOW TO UNDERSTAND IT	METRICS
COMPANY ENVIRONMENTAL IMPACT IMPROVEMENT - ACTIVITY BENCHMARKING AVERAGE	The “CEI-Activity Benchmarking Average” is a positive or negative number that accounts for the percentage of change in the “CER-Activity Benchmarking Average” for the company. Thus, the “CEI-Activity Benchmarking Average” compares the current ranking of the company’s facilities regarding the industrial activity average, with the ranking of the three previous years (i.e., the percentage of variation in rankings of the environmental score for the facilities of the analyzed company).	The "CEI-Activity Benchmarking Average" allows us to evaluate whether the company is improving or worsening the impact ranking of its facilities in their respective activities over time. A value of -100 means that the company has gone from having all of its facilities in the worst possible position to the best possible position. Any negative value shows a positive evolution, while positive values mean that the ranking of the company's facilities, on average, are worse off in their respective activities. A zero shows no change in the relative positions of its facilities. For example, if the company's facilities currently have an average position of 50 and in the past (average of the previous three years) it was 60, the score for the index will be = -10*100/60 = -16.67% (i.e., the companies' facilities, on average, are improving their relative positioning by 16.67%).	The "CEI-Activity Benchmarking Average" represents the evolution of the company over time, considering the relative position of its facilities in their respective industrial activities.
COMPANY PREDICTABILITY OF ENVIRONMENTAL IMPACT	The “CPEI” is the relative difference between the company’s actual value for its environmental impact score in the latest year available and the prediction that results from previous years’ values.	The "CPEI" is meaningful to assess the volatility of the environmental risks in a certain company. The "CPEI" is a proxy of the unexpected changes in the environmental risks of a company. From a different perspective, the "CPEI" shows the difference between the environmental score in the company and the expected environmental score in a similar one.	The “CPEI” results from the difference between the actual environmental score that a company has for the latest year, and the prediction that was made for that year based on previous data. We calculate these differences by aggregating the differences in the actual and predictive values of all the company facilities. The predictive value comes from a panel data analysis that includes the environmental scores for all the facilities in our database and the control variables of activity, country, and year.

Table 5.4. Indexes for Region levels

INDEX	DEFINITION	HOW TO UNDERSTAND IT	METRICS
REGION ENVIRONMENTAL IMPACT RANKING-TOTAL	The "RER-Total" index measures the environmental impact of the analyzed region comparing it with others in our database (eg. a 60 means that the environmental impact of the analyzed region is higher than that of 60% in our database).	The "RER-Total" index ranks the environmental risks of a region by comparing it with others. Regions with higher environmental risks have higher values in the index (e.g. an 80 means that the environmental impact score of the analyzed region is higher than that of 80% of regions in the database). This index acquires an additional value if you use it for comparing the historical ranking within the region, or comparing different regions. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the final score of a region (e.g. the industrial sector of a region may generate a higher environmental impact than that of regions with more environmentally friendly industries). In any case, a region with a high "RER-Total" score should pay extra attention to its environmental risks.	The "RER-Total" index is a number that ranges from 0 to 100. It reflects the percentage of regions in our database that have a lower environmental impact score than the analyzed region.
REGION ENVIRONMENTAL IMPACT RANKING-AVERAGE	The "RER-Average" index measures the percentage of facilities in our database that have a lower environmental impact than those in the analyzed region in the same industrial activity (eg. a 60 means that the environmental impact of the region's facilities is higher than that of 60% of the rest of their competitors in our database).	The "RER-Average" index ranks the environmental risks of a region comparing its facilities to others in the same industry. Regions with higher environmental risks have higher values in the index (e.g. an 80 means that the environmental impact score of the facilities in the analyzed region is higher than that of 80% of facilities in the database). This index acquires an additional value if you use it for comparing the historical ranking within the region, or comparing different regions with similar industrial activities. Bear in mind, a high score in this index does not necessarily carry negative implications. This is because many factors may influence the final score of a region (e.g.a region with a high number of dirty industries may generate a higher environmental impact than that of regions with more environmentally friendly industries). In any case, a region with a high "RER-Total" score should pay extra attention to the environmental risks of its facilities.	The "RER-Average" index is a number that ranges from 0 to 100. It reflects the percentage of facilities in our database that have a lower environmental impact score than those in the analyzed region.