M2 EEE Database Management Systems

Observatory of Environmentally-Friendly Companies (OEFC)

Andrew Boomer,

Jacob Pichelmann

December 18, 2020

Table of Contents

1 Introduction

The Covid-19 pandemic direly exposed the fragility of our social and economic system and might serve as a harbinger of what humanity awaits if we fail to act on the dawning climate crisis. Acknowledging the urgency of the situation, the Observatory of Environmentally-Friendly Companies (OEFC) aims to promote green initiatives of companies by establishing a knowledge pool which ultimately serves to promote, monitor and analyze green actions conducted by companies. To this end, the OEFC offers a web-based tool which gives an overview of all possible green actions, the companies which have adopted them and those offering services to support them. Moreover, the impact of said actions is analyzed by year to year comparison where the measure of success is defined as a reduction in CO2 emissions. This paper provides an overview about both the underlying conceptual structure of said tool as well as its technical implementation. Additionally, a user guide is provided which allows users to navigate the resulting application effortlessly, regardless of prior technical know-how. The paper is hence structured as follows: First, the introduction continues with a description of groups of potential users and offers a discussion of the universe that is modelled. Second, an entity relationship model of this universe is introduced. Third, the entity relationship model is translated into a relational model. Fourth, having derived all conceptual components, the construction of the database in SQLite is briefly described and the data sources are outlined. Fifth, the functionality of the database and the application built on top of it is illustrated by executing a set of queries and analyses. Lastly, a user guide explains the few steps necessary to successfully launch and navigate the application.

1.1 Potential users

The resulting webtool serves as an informational tool for a wide set of users. The following groups can be distinguished:

- ▷ Companies that would like to be aware of green initiatives, plan to invest in environment friendly actions and/or look for examples of such actions and how they

could be funded;

- ▷ Companies that have already invested in such actions and want to communicate about them, and therefore, improve their own reputation;
- ▷ Consumers who would like to select products or services on the basis of their green quality;
- ▷ Citizens, notably students, who would like to select companies for a job or an internship, according to their green behavior and reputation.

1.2 Description of the universe to be modelled

The main agent in this universe is a **company** which can conduct and support actions, apply for funding and whose environmental performance is recorded. In this regard, the following information is registered per year: the quantity of carbon emissions, the turnover, the total amount of investment in green actions and the number of recruitments related to green actions.

A company is known by its name, its main location (city & country), its website address, its sector (energy, agriculture, aircraft construction, transport ...), its size, the actions it has carried out, and the type of actions it can support or certify. Certification consists in guaranteeing with a label the quality or the realization conditions of an action.

An action type has:

- ▷ a category (production, service, internal behavior, external behavior, financing...);
- ▷ a description (using renewable energy, offsetting of travel emissions, usage of green bonds, phasing out of plastic straws, ...);
- ▷ its main impact (emission reduction, pollution prevention, perseverance of biodiversity ...);

▷ possible public and/or private funding programs to implement that type of actions.

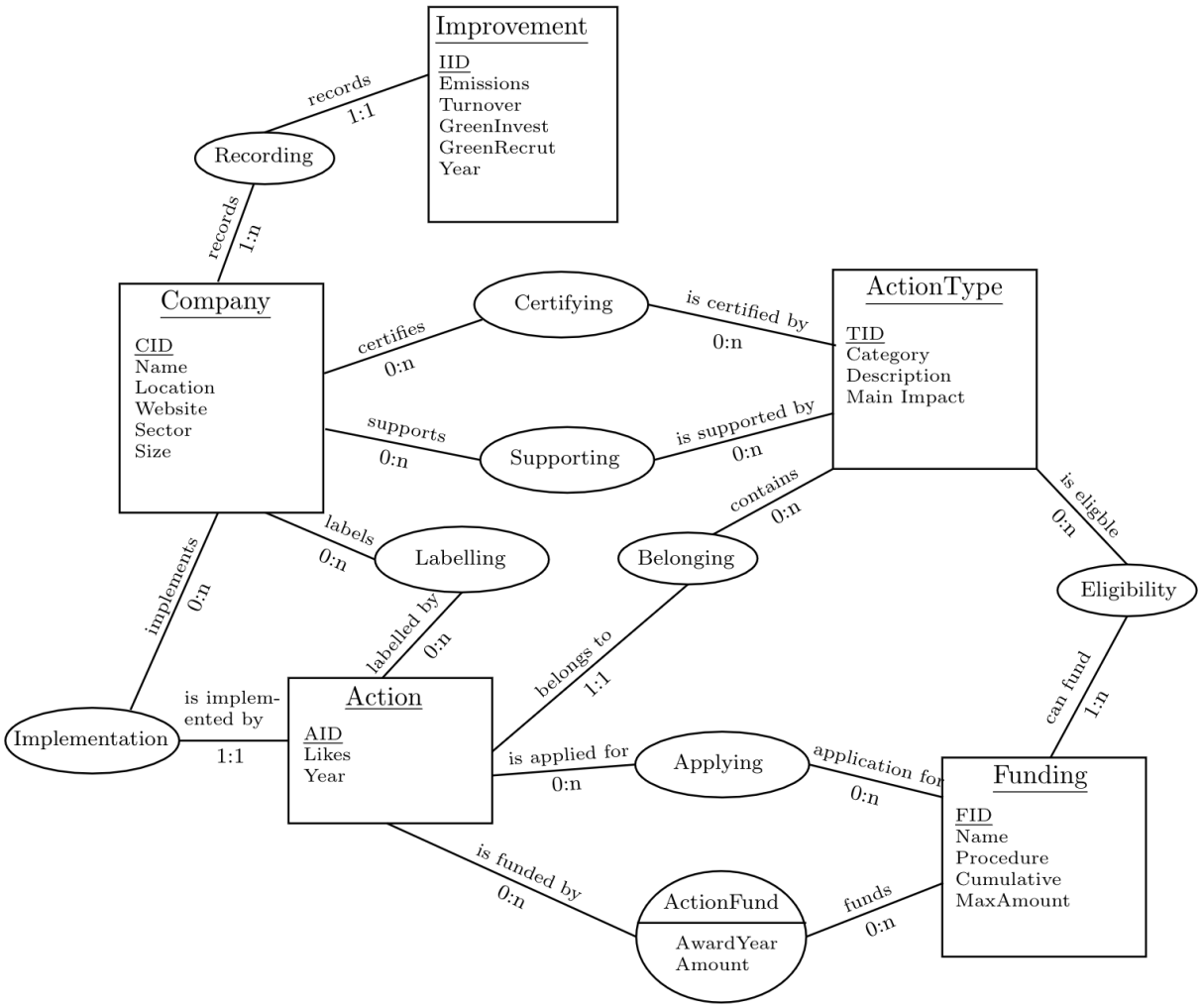
An action is implemented a given year by a company, belongs to a type of actions, is certified or not by another company and may have been funded after applying to funding program(s). We also record the number of likes received by each action.

A funding program is known by its name, a maximum allowable amount by action, its eligible types of actions, a procedure (text or link towards a web page explaining the procedure) and if it is cumulative or not with other programs. For each company, each of the granted (funded) actions must be recorded with the corresponding funding program, its year of obtainment and amount.

2 Entity Relationship Model

We use an entity relationship (ER) model to graphically represent the universe outlined above. In a nutshell, the ER model depicts the objects of the universe (entities) and the relations between those objects. In this context an entity can be anything that can exist independently and can be identified uniquely. To put this in layman terms, an entity is essentially some aspect of the universe that can be distinguished from other aspects of the same universe. Relationships, on the other hand, capture how entities are related to one another. A relationship is hence an association among two or more entities. Putting this theoretical definition to work, we first identify the natural entities of the universe given. We then proceed by modelling the associations between said entities, which build on a set of assumptions that are outlined in section 2.1. The resulting entity relationship schema is displayed in figure 1. Note that the unique identifier of each entity is underlined. The domain of each attribute is given in the relational model in section 3.

Figure 1: Entity Relationship Model



2.1 Assumptions

The associations between entities are modelled based on the following set of assumptions:

- ▷ Each improvement record corresponds to one and only one company.
- ▷ Each action belongs to one and only one action type.
- ▷ The source of likes of an action is not of interest, we only record the amount.
- ▷ Each funding program must fund at least one action type.
- ▷ Each company must have at least one record in the improvements table.
- ▷ One instance of an action is implemented by exactly one company.

2.2 Integrity Constraints

Additionally, we the inserted data has to pass a set of integrity checks, namely:

1. The funding amount must be greater than 0.
2. The maximum amount per funding program must be greater than 0.
3. The funded amount cannot be greater than the maximum amount per action of a funding program.
4. The funded action must be in the set of eligible actions of a funding program.
5. The label must come from a company who is able to certify the action type the action belongs to.
6. AwardYear must be less or equal to Action.Year, i.e. an action cannot be funded after it was implemented.
7. Actions can be funded by multiple funding programs only if all of them are cumulative.

Integrity constraints (3) to (7) are cross-table constraints, which means they require a subquery in order to check whether the constraint has been violated. In SQLite, subqueries cannot go into a check constraint, so we had to implement these integrity constraints in a different way. Our solution for this was to use the "CREATE TRIGGER" function.

For Integrity Constraint (3) this query is:

```
CREATE TRIGGER amount_check
BEFORE INSERT ON ACTIONFUND
WHEN NEW.AMOUNT > (
SELECT DISTINCT FUNDING.MAXAMOUNT
FROM FUNDING, ACTIONFUND
WHERE FUNDING.FID = ACTIONFUND.FID)
BEGIN
SELECT RAISE(FAIL, 'Funded Amount Cannot Be Greater Then
   Max Amount');
END;
```

For Integrity Constraint (4) this query is:

```
CREATE TRIGGER aid_check
BEFORE INSERT ON ACTIONFUND
WHEN NEW.FID NOT IN (
SELECT DISTINCT ELIGIBILITY.FID
FROM ACTION, ELIGIBILITY
WHERE ACTION.AID = NEW.AID
AND ACTION.TID = ELIGIBILITY.TID)
BEGIN SELECT RAISE(FAIL, 'Funding Program not in List of
  Eligible Programs for this Action Type'); END;
```

For Integrity Constraint (5) this query is:

```
    CREATE TRIGGER cert_check
    BEFORE INSERT ON LABELLING
    WHEN NEW.CID NOT IN (
    SELECT DISTINCT CERTIFYING.CID
    FROM ACTION, ACTIONTYPE, CERTIFYING
    WHERE NEW.AID = ACTION.AID
    AND ACTION.TID = CERTIFYING.TID)
    BEGIN
    SELECT RAISE(FAIL, 'Company Cannot Label This Type Of
       Action');
    END;
```

For Integrity Constraint (6) this query is:

```
CREATE TRIGGER year_check
BEFORE INSERT ON ACTIONFUND
WHEN NEW.AWARDYEAR > (
SELECT DISTINCT ACTION.YEAR
FROM ACTION
WHERE ACTION.AID = NEW.AID)
BEGIN SELECT RAISE(FAIL, 'Funding Award Year Cannot After
   Action Year');
END;
```

For Integrity Constraint (7) this query is:

```
    CREATE TRIGGER cumulative_check
    BEFORE INSERT ON ACTIONFUND
    WHEN NEW.FID IN (
    SELECT DISTINCT FID
    FROM(
```

```
6         SELECT 1 as Holder, ACTIONFUND.FID
7         FROM ACTIONFUND, FUNDING
8         WHERE ACTIONFUND.FID = FUNDING.FID
9         AND FUNDING.CUMULATIVE = 'FALSE'
10    ) GROUP BY Holder
11    HAVING COUNT(FID) > 1)
12    BEGIN SELECT RAISE(FAIL, 'Funding Program is Not
          Cumulative, Cannot Support Multiple Actions');
13    END;
```

Finally, to ensure there were no unintended integrity constraint conflicts, the **ActionFund** table was filled last. If data that does not satisfy the integrity constraints is placed in the source files of the database, the user will receive and error when trying to fill the database that indicates which constraint was violated. The faulty data can then be easily changed accordingly. An example of such an error is shown in figure 2.

Figure 2: Example of Integrity Constraint Violation

```
sqlite3.IntegrityError: Funding Award Year Cannot After Action Year
```

3 Relational Model

We can transform the ER model into a relational model by following three steps.

1. We start by constructing a table for each entity class, namely **Improvement, Company, Action, ActionType** and **Funding**. The name of the entity becomes the table name, the entity's properties become the table's attributes and finally the unique identifier of each entity translates to the primary key of the resulting table.

2. In the second step we design additional tables for all *many to many* relationships that this ER model includes. From this procedure we obtain six additional tables: **Supporting, ActionFund, Applying, Certifying, Labelling** and **Eligibility**.

The primary keys of these tables are the tuples of their foreign keys, shown in greater detail below. Foreign keys are indicated with a star *.

3. Lastly, we account for the remaining associations by adding them as foreign keys to the existing tables where the underlying cardinality is one.

Implementing these steps yields the following relational model:

- ▷ Action(AID : int; Likes : int; Year : int, CID*, TID*)
- ▷ ActionType(TID : int; Category : varchar(100); Description : varchar(500); MainImpact : varchar(100))
- ▷ Improvement(IID : int, Emissions : double; Turnover : double; GreenInvest : double; GreenRecrut : int, Year: int; CID*)
- ▷ Company(CID : int; Name : varchar(100); Location : varchar(100); Website : varchar(100); Sector : varchar(100); Size : double)
- ▷ Eligibility(FID*, TID*)
- ▷ Certifying(CID*, AID*)
- ▷ Labelling(CID*, AID*)
- ▷ Supporting(CID*, AID*)
- ▷ Applying(FID*, AID*)
- ▷ ActionFund(FID*, AID*; AwardYear : int; Amount : double)

4 Generating and Filling the Database

The backend of OEFC's webtool runs on an SQLite database which is filled automatically from a Python scraping script. In the current implementation a google sheet document that contains all collected data is scraped. However, if there were data sources for all

necessary data points, the script could easily be changed to retrieve data from said sources, e.g. APIs. This backend implementation hence comprises a lot of flexibility as new data can be inserted easily. In order to cater to the number of different users with different levels of technical knowledge we additionally built a desktop application which performs a set of analyses described in greater detail in section 5. Moreover, this application also updates the database with every run meaning that the analysis is always conducted on the most recent set of data.

4.1 Companies

As examples for companies observed by OEFC we chose a set of 11 companies that cover a broad spectrum of business activity and are situated in different geographical regions. We include both well established firms such as Volkswagen and Walmart as well as new and disruptive ventures such as Tesla and Spotify. Arguably older companies, especially those operating in areas with likely harmful environmental consequences, such as Total SE and Volkswagen face greater pressure from the public to operate in a way that protects the environment. We are interested to see how this reflects in both their environmental performance and their actions.

4.2 Improvement (Environmental Statistics)

Again, we collected real world data from business and sustainability reports to fill this table meaningfully. The turnover of each of the companies in our sample is publicly disclosed hence those values can be taken at face value. The CO2 emissions, however, are often only listed in reports spanning hundreds of pages and are frequently given by source of emissions, e.g. production or business related travel. The resulting data is hence an approximation of the total level of CO2 emissions and can be interpreted in relative terms for one company (over time) but should be taken with a grain of salt when comparing emissions between companies. Similarly, the data on green investments is not available in an aggregated format, resulting in approximate values taken from the

respective sustainability reports. Unfortunately there is no public information available on the number of recruitments that resulted from a company's green actions. We hence approximated this value by assessing each company's *attractiveness* for individuals looking to employ their skill set in an environmentally friendly context (e.g. Tesla supporting the shift to electric vehicles and solar energy is perceived as positive whereas the Diesel scandal led to Volkswagen's reputation being shattered) and set this in relation to the total number of employees of each company to derive an approximation.

4.3 Action Types

We manually collected a set of eight different action types, with we obtain from companies' sustainability reports and general online press releases. As this is part of their marketing it was often a challenge to distinguish between companies' goals and their actual implementation of actions but the resulting data indeed captures past behaviour of firms. Fortunately many types of actions are taken by different companies which allows for meaningful comparison.

4.4 Actions

With a total of 19 actions we succeeded in collecting at least one action for each company and multiple actions for some, which provides a good basis for analysis. However, even after consulting the sustainability reports, there was often no indication when a given action was implemented. The indicated year is hence just an approximation based on the assumption that actions have been implemented shortly before being communicated in reports and press releases.

4.5 Labelling, Supporting, Certifying

After an extensive research endeavour we were unable to find any information on companies supporting, certifying or labelling specific environmental actions. The data on these interlinkages is hence based on the company's environmental history. We were able

to research, for instance, that Volkswagen led the initiative of reusing old parts hence we assign it the capability of supporting and labelling in this area. Similarly, Spotify early on discussed the significant role of business related air travel, prompting us to give them a *first mover* status in this context. It has to be kept in mind, however, that these interlinkages are not derived from actual quantifiable data.

4.6 Funding Programs

There is no publicly disclosed information whether or not a company profits from a funding program when implementing a green action. We therefore researched on funding programs to then match them to the action types we obtained from the sustainability reports. Most such funding programs are provided by the government and in fact intend at supporting small and medium size enterprises which is at odds with the firms we have in our sample. The key areas of support are green energy and waste reduction. Motivated by these observations we manually design five different funding programs which take their inspiration from real government programs but are in fact completely fictive.

5 Measuring Companies' Environmental Performance

We analyze the data through three distinct packages, each consisting out of a set of queries. Some results are additionally highlighted with figures. For each set we show the required information and the query that was implemented to obtain said information. In some instances additional remarks are noted.

5.1 Package 1: Making companies aware of green initiatives by sector

Table 1: Query F1 - F1.5

Showcase functionality of view F1.

```
1 SELECT * FROM ActionsInTechnology
```

CID	Name	AID
3	Apple	1
1	Alphabet	4
3	Apple	8
3	Apple	9
10	Snapchat	12
11	Spotify	13
11	Spotify	17

Remark F1: We only show the resulting view, the underlying SQL code to produce this view can be seen when using the desktop application. As the view serves to display the companies of a *given* sector, we allow the user to make a choice on the sector, when using the app. There is hence great flexibility accounting for different user interests. In the example displayed in this report *Technology* has been chosen.

Table 2: Query R1

Information about the evolution through time of companies of a given sector.

```
SELECT IMPROVEMENT.*, COMPANY.NAME
FROM COMPANY, IMPROVEMENT
WHERE COMPANY.CID = IMPROVEMENT.CID
AND COMPANY.SECTOR = 'Technology'
```

IID	Emissions	Turnover	GreenInvest	GreenRecruit	CID	Year	Name
1	3.29491e+06	110855	4000	1200	1	2017	Alphabet
2	1.50272e+07	136819	3700	8000	1	2018	Alphabet
3	8.57655e+06	161857	6500	8430	1	2019	Alphabet
7	2.71e+07	247510	423	12000	3	2017	Apple
8	2.46e+07	260170	530	14230	3	2018	Apple
9	2.41e+07	265600	588	17400	3	2019	Apple
28	50000	825	5	0	10	2017	Snapchat
29	43000	1180	7	20	10	2018	Snapchat
30	38000	1716	10	70	10	2019	Snapchat
31	15000	1200	125	5	11	2017	Spotify
32	18000	4320	120	12	11	2018	Spotify
33	19400	6760	194	25	11	2019	Spotify

Remark R1: Similar to the prior query the user is again presented with the choice of sector. Again we chose *Technology* as an example.

Figure 3: Query R2

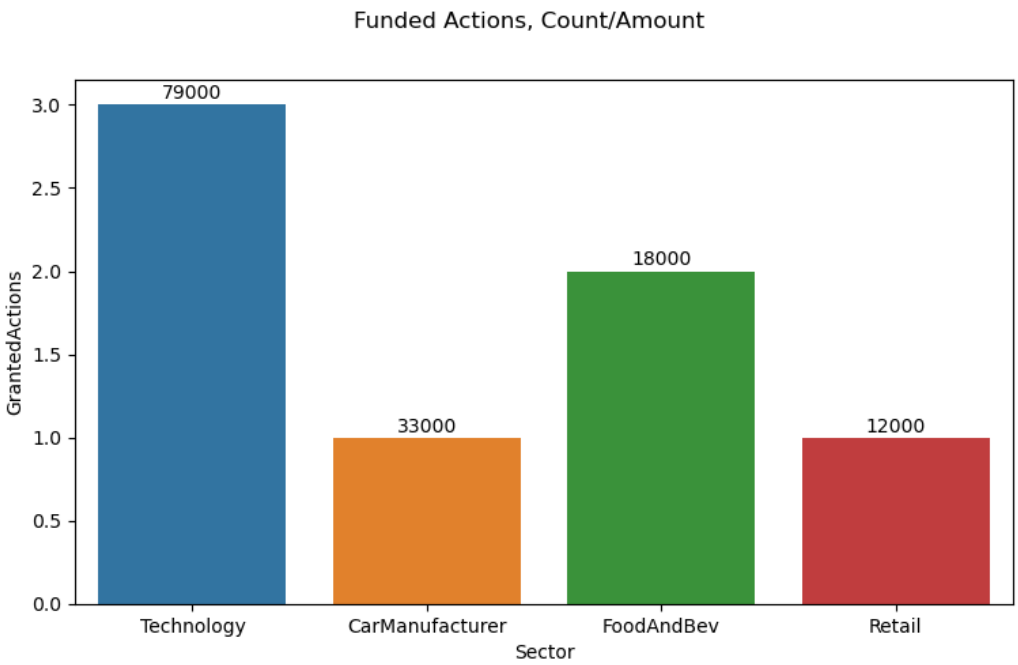


Table 3: Query R2

Number of granted (funded) actions and the total amount of grants received by sector. Limit to sectors having received more than X grants and sort according to the amount. Give also a graphic representation of the answer.

```
SELECT COMPANY.SECTOR,
    COUNT(ACTIONFUND.FID) As GrantedActions,
    SUM(ACTIONFUND.Amount) as TotalAmount
FROM COMPANY, ACTION, ACTIONFUND
WHERE COMPANY.CID = ACTION.CID
AND ACTION.AID = ACTIONFUND.AID
GROUP BY COMPANY.SECTOR
HAVING GrantedActions > 0
ORDER BY TotalAmount DESC
```

Sector	GrantedActions	TotalAmount
Technology	3	79000
CarManufacturer	1	33000
Food&Bev	2	18000
Retail	1	12000

Remark R2: As funding is scarce, we limit the query to sectors having received more than 0 grants. However, this could (and should) be changed when more data is available.

Table 4: Query R3

For each type of actions display the companies that can help for its realization.

```
SELECT ACTIONTYPE.TID, ACTIONTYPE.DESCRIPTION,
    COMPANY.CID, COMPANY.NAME
FROM ACTIONTYPE, CERTIFYING, COMPANY
WHERE COMPANY.CID = CERTIFYING.CID
AND ACTIONTYPE.TID = CERTIFYING.TID
```

TID	Description	CID	NAME
1	Usage of renewable energy	7	Siemens
4	Set up of charging stations of electric cars	8	Tesla
5	Reusage of old components	5	Volkswagen
7	Offsetting of travel emissions	11	Spotify
1	Usage of renewable energy	8	Tesla
1	Usage of renewable energy	5	Volkswagen

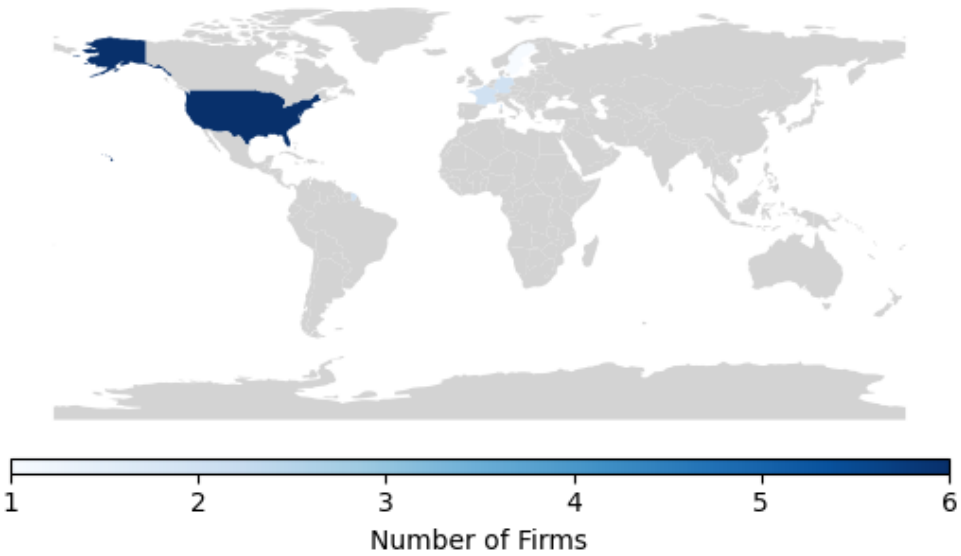
Table 5: Query R4

Number of companies by location. Give a world map chart (import in excel the data..., look for a tutorial about that).

```
SELECT Country, COUNT(CID) as NumCompanies
FROM COMPANY
GROUP BY Country
ORDER BY NumCompanies DESC
```

Location	NumCompanies
United States of America	6
Germany	2
France	2
Sweden	1

Figure 4: Query R4



5.2 Package 2: Reputation and evolution of analysis of companies

Table 6: Query R5

Companies in the decreasing order of the total number of likes they got through their actions.

```
SELECT COMPANY.CID, COMPANY.Name,
    SUM(ACTION.Likes) AS NumLikes
FROM ACTION, COMPANY
WHERE ACTION.CID = COMPANY.CID
GROUP BY COMPANY.Name
ORDER BY NumLikes DESC
```

CID	Name	NumLikes
8	Tesla	1877000
10	Snapchat	1430000
3	Apple	1230000
11	Spotify	1070000
2	Starbucks	650000
6	Walmart	162000
1	Alphabet	120000
5	Volkswagen	98000
4	Airbus	32000
9	Total SE	12000
7	Siemens	11300

Table 7: Query R6

The company that got the most number of certified actions.

```
SELECT COMPANY.CID, COMPANY.Name,
COUNT(LABELLING.AID) as NumCerts
FROM COMPANY, LABELLING, ACTION
WHERE COMPANY.CID = ACTION.CID AND
LABELLING.AID = ACTION.AID
GROUP BY COMPANY.CID, COMPANY.Name
ORDER BY NumCerts DESC LIMIT 3
```

CID	Name	NumCerts
6	Walmart	2
4	Airbus	1
8	Tesla	1

Remark R6: We limit the output to the top 3 observations instead of just showing the top one, as it might happen that companies have the same number of certified actions, which is indeed the case in our data.

Table 8: Query R7

Companies that propose help and also provide certifications.

```
SELECT DISTINCT comb.CID, COMPANY.Name
FROM(
    SELECT DISTINCT CID
    FROM SUPPORTING

    UNION ALL

    SELECT DISTINCT CID
    FROM CERTIFYING
) comb, COMPANY
WHERE comb.CID = COMPANY.CID
```

CID	Name
3	Apple
5	Volkswagen
8	Tesla
11	Spotify
7	Siemens

Table 9: Query R8

Companies whose green situation has been improved between two given years: the quantity of carbon emissions decreases.

```
SELECT COMPANY.CID, COMPANY.Name,
    sum(Emissions) filter(where Year = 2018) -
       sum(Emissions) filter(where Year = 2017) Diff20182017,
    sum(Emissions) filter(where Year = 2019) -
       sum(Emissions) filter(where Year = 2018) Diff20192018
FROM COMPANY, IMPROVEMENT
WHERE COMPANY.CID = IMPROVEMENT.CID
GROUP BY COMPANY.CID
HAVING Diff20182017 < 0 OR Diff20192018 < 0
```

CID	Name	Diff_2018_2017	Diff_2019_2018
1	Alphabet	1.17323e+07	-6.45067e+06
2	Starbucks	61000	-325000
3	Apple	-2.5e+06	-500000
4	Airbus	310000	-680000
5	Volkswagen	160000	-1.6e+06
6	Walmart	-1.154e+06	-120000
7	Siemens	-2.001e+06	-160000
9	Total SE	-2.5e+06	-1.9e+06
10	Snapchat	-7000	-5000

Remark R8: We track environmental data of companies between 2017 and 2019. We can therefore check two pairs of years and see if the company's environmental situation has improved from one year to another. Interestingly we find that for some companies (Starbucks, Airbus, Volkswagen) the situation did not improve between 2017 and 2018 but then they were able to turn it around and indeed improved between 2018 and 2019. We would not have been able to spot this development if we would have analyzed only two years. Moreover, we find that the situation got worse over time for Tesla and Spotify, as they are not displayed in the query result. This can, however, be attributed to the fact that these are both strong growth companies where a rise in emissions mainly stems from a significant increase in business activity.

5.3 Package 3: Analysis of the funding programs

Table 10: Query F2 - F2.5

Showcase functionality of view F2.

```
SELECT * FROM EligibleTypes
```

FID	Name	TID	Description
1	Clean Energy for All	1	Usage of renewable energy
2	Clean Ocean Initiative	2	Phasing out of plastic straws
3	Waste Reduction Program	2	Phasing out of plastic straws
4	Fly Green	7	Offsetting of travel emissions
5	Recycling Rocks!	5	Reusage of old components
1	Clean Energy for All	4	Set up of charging stations of electric cars

Remark F2: We again only show the resulting view. The underlying SQL code to construct this view can be seen when using the desktop application.

Table 11: Query R9

Evolution of the investment of a given company per year: number of recruitments, the percentage of green investment compared to the amount of turnover. Give also a graphic representation.

```
SELECT COMPANY.CID, COMPANY.Name, Year,
    GreenRecruit, GreenInvest, Turnover,
    (GreenInvest/Turnover)*100 AS GreenInvestPercentage
FROM COMPANY, IMPROVEMENT
WHERE COMPANY.CID = IMPROVEMENT.CID
AND COMPANY.NAME = 'Alphabet'
```

CID	Name	Year	GreenRecruit	GreenInvest	Turnover	GreenInvestPercentage
1	Alphabet	2017	1200	4000	110855	3.60832
1	Alphabet	2018	8000	3700	136819	2.7043
1	Alphabet	2019	8430	6500	161857	4.01589

Remark R9: As in Query F1 and R1 we again let the user choose which company to analyze. For this report we chose *Alphabet* as an example.

Figure 5: Query R9

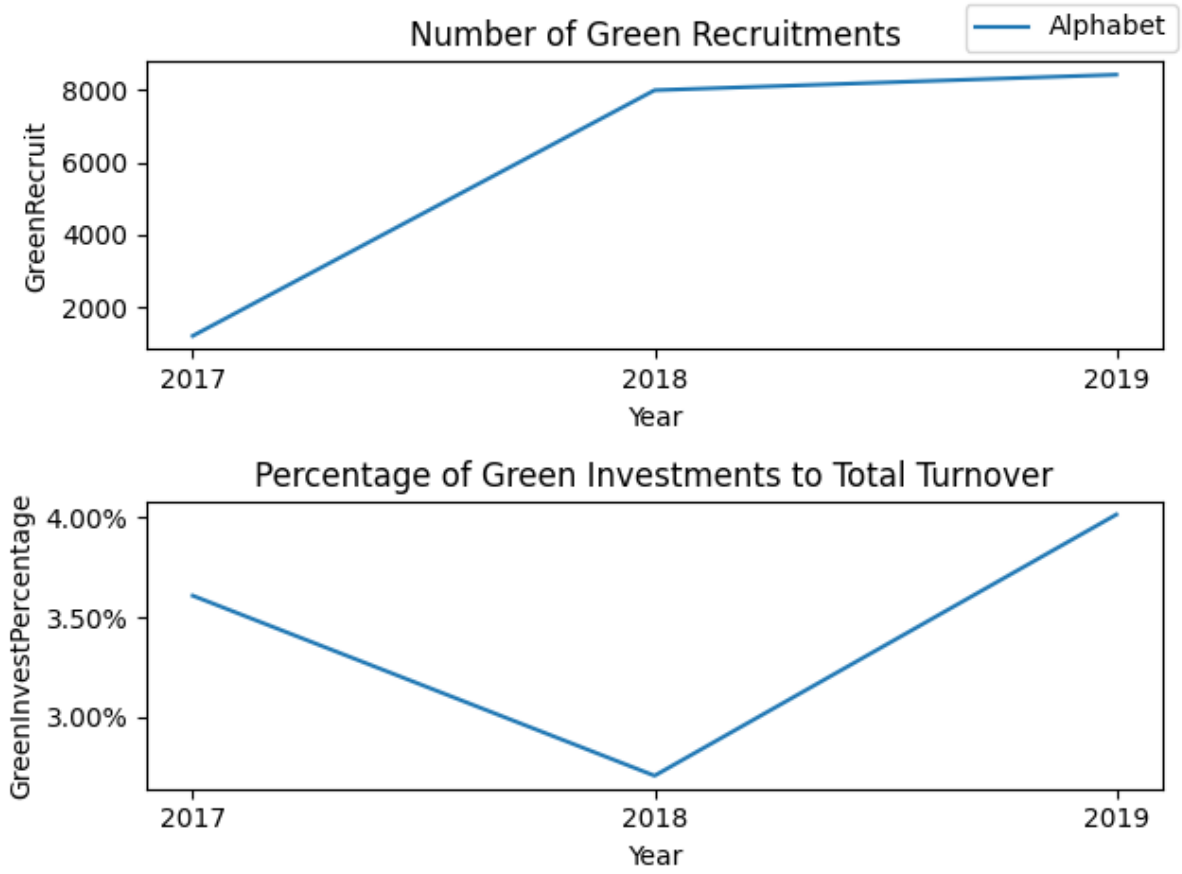


Table 12: Query R10

Average, max and min amounts of grants and number of grants attributed by each Funding program.

```
SELECT FUNDING.FID,
    AVG(ACTIONFUND.Amount) as AvgAmount,
    MAX(ACTIONFUND.Amount) as MaxAmount,
    MIN(ACTIONFUND.Amount) as MinAmount,
    COUNT(ACTIONFUND.AID) as NumGrants
FROM FUNDING, ACTIONFUND
WHERE FUNDING.FID = ACTIONFUND.FID
GROUP BY FUNDING.FID
```

FID	AvgAmount	MaxAmount	MinAmount	NumGrants
1	23000	34000	12000	2
2	10000	10000	10000	1
3	8000	8000	8000	1
4	5000	5000	5000	1
5	36500	40000	33000	2

Table 13: Query R11

Types of actions without funding program.

```
SELECT ACTIONTYPE.TID, ACTIONTYPE.DESCRIPTION
FROM ACTIONTYPE
WHERE ACTIONTYPE.TID NOT IN(
SELECT ACTION.TID FROM
ACTION, ACTIONFUND
WHERE ACTION.AID = ACTIONFUND.AID)
```

TID	Description
3	Usage of green bonds
6	Management remuneration based on CO2 emission levels
8	Supporting biodiversity

Remark R11: We interpret this OEFC request as checking which implemented actions belong to types that for which no funding program is available. Another interpretation would be to check which types of actions are not eligible for funding, but this can be easily derived from the **Eligibility** table.

Table 14: Query R12

Evolution by year of the total amount received by granted actions. Draw also a graphic.

```
SELECT AwardYear, SUM(Amount) as YearlyAmt
FROM ACTIONFUND
GROUP BY AwardYear
```

AwardYear	YearlyAmt
2017	33000
2018	40000
2019	51000
2020	18000

Figure 6: Query R12

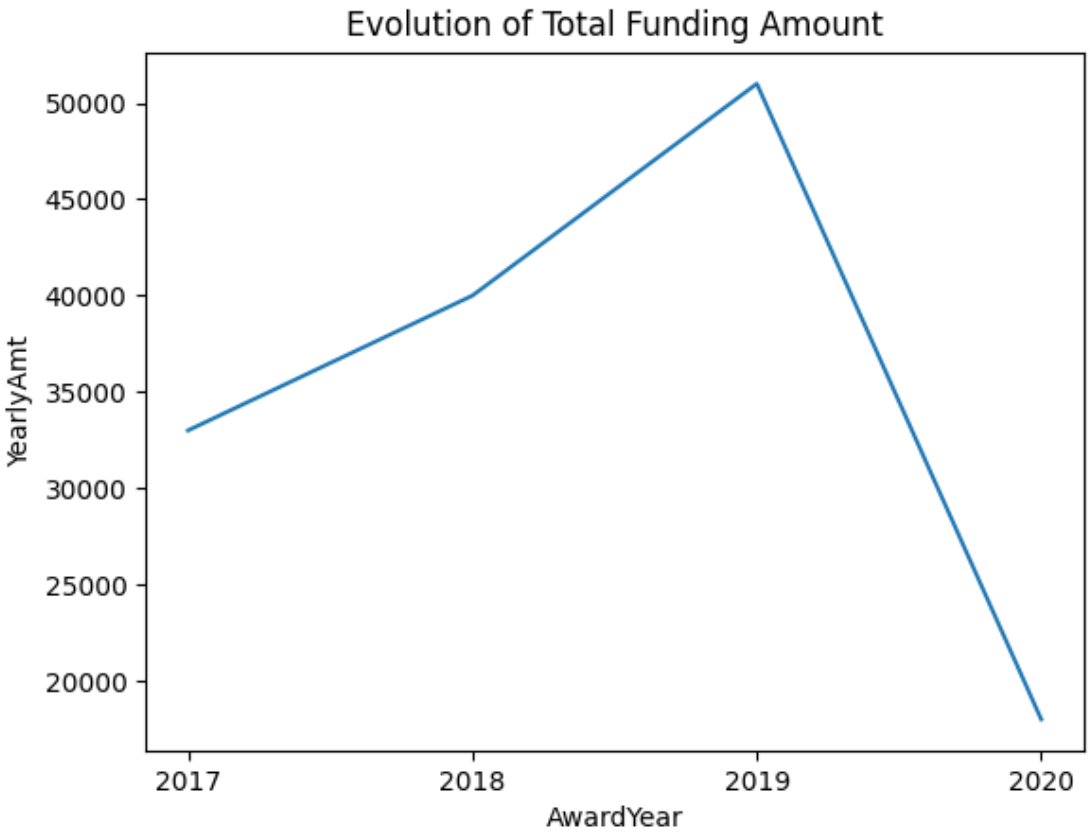


Table 15: Query R13

Percentage of actions that were funded.

```
SELECT 100 * CAST(Funded AS DECIMAL) / CAST(AllActions AS
   DECIMAL) as PctFunded
FROM(
    SELECT 1 As Holder, COUNT(AID) As Funded
    FROM ACTIONFUND
    GROUP BY Holder
) AS left
JOIN (
    SELECT 1 As Holder, COUNT(AID) As AllActions
    FROM ACTION
    GROUP BY Holder
) AS right
ON left.Holder = right.Holder
```

PctFunded
36

5.4 Forecasting future number of actions

To forecast the future number of actions, we built a time series model which takes in data from the previous year to make forecasts. Our model is of the form:

$$Actions_t = \alpha Actions_{t-1} + \beta Likes_{t-1} + \delta Size_{t-1} + \epsilon_t$$

From this, a vector of $\Big(Actions_t, Likes_t, Size_t\Big)$ can be used to predict $Actions_{t+1}$. The underlying rationale is that the past number of actions, as well as their perception by the public (likes) and the company's size (i.e. their power and resources) are suitable determinants of the future number of actions.

The query to gather the data for this forecast, as well as the forecast plot are shown in Table 16 and Figure 7. We expect the number of actions to increase to 13 in 2021. This is, however, only a tentative forecast, given the limited number of data points.

Table 16: Forecasting the Number of Future Actions

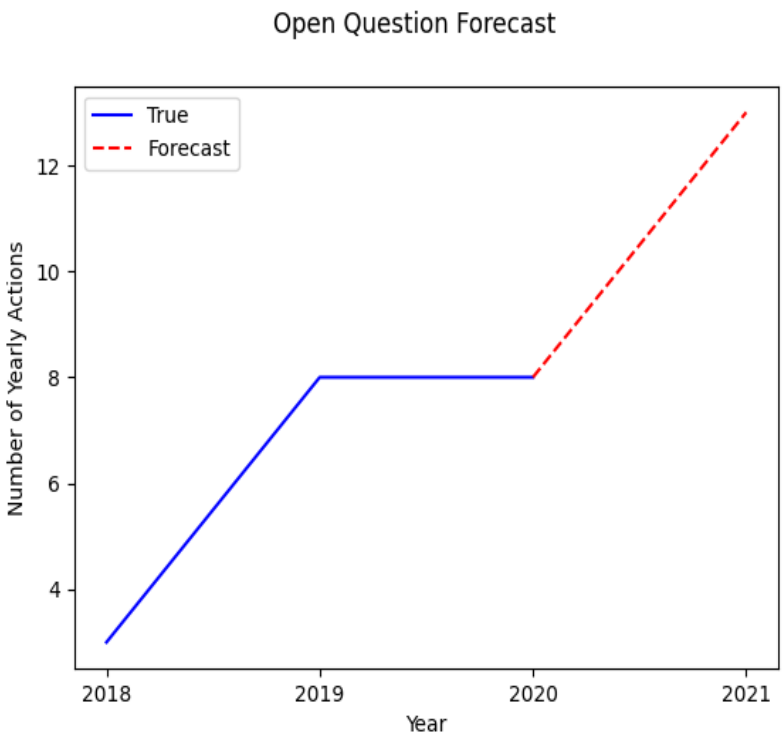
Taking all the necessary assumptions and using the tools of your choice (R, Python...) combined with SQL, try to forecast how the number of actions will evolve in the future

```sql
SELECT ACTION.YEAR, AVG(COMPANY.SIZE) as Size,
    SUM(ACTION.LIKES) as NumLikes,
    COUNT(ACTION.AID) as NumActions
FROM COMPANY, ACTION
WHERE COMPANY.CID = ACTION.CID
GROUP BY ACTION.YEAR

NumActions(t) = A*Size(t-1) + B*NumLikes(t-1) +
   C*NumActions(t-1)
```

	Year	Prediction
0	2018	3
1	2019	8
2	2020	8
0	2021	13

Figure 7


Open Question Forecast
True
Forecast
Number of Yearly Actions
12
10
8
6
4
2018
2019
2020
2021
Year

6 User Guide

In order to cater to the needs of different users we constructed a desktop app running on Python that allows to navigate analysis. We built a graphical user interface (GUI) based on the Python package Tkinter to offer a user-friendly way to interact with the database. To start the app the following steps have to be followed:

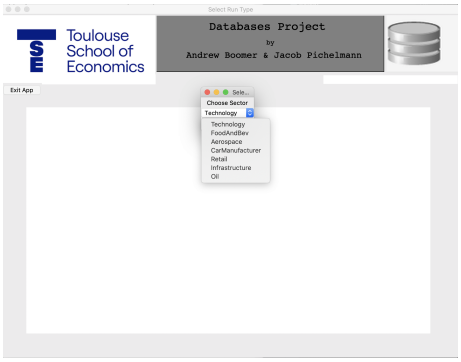
1. Unzip the compressed file.
2. Open Terminal on Mac or Command Prompt on Windows.
3. Navigate to the "Code" folder within the unzipped file using Terminal or Command Prompt.
4. Run the App.py file using your python executable. Depending on your python configuration, this could be "python App.py", "python3 App.py", or "python -m run App.py".
5. The code uses the Python Install Packages (pip) library to download any needed packages that are not currently installed on the user's machine.
6. If the app is accidentally closed before intended, the user is advised to redo Step 4 in Terminal or Command Prompt to restart the App.

Alternatively, the app can of course also be executed from the user's python editor of choice. Examples of the app's functionality are displayed in figure 8.

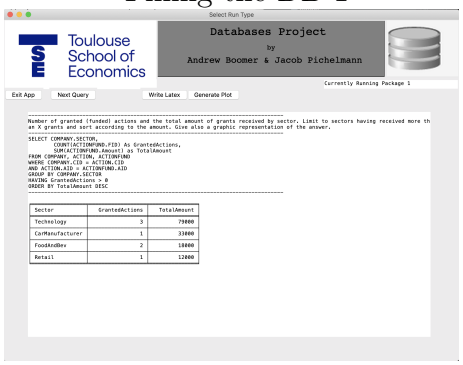
Once the app is up and running the navigation is very intuitive. The queries can be executed sequentially and each result can be exported to LaTeX. Additionally, for some queries there is the option to visualize the result. The resulting plot is then displayed in the app and will be automatically saved to the output folder. Note that this app re-fills the database with the most recent data in the google sheet for each run. It hence inserts the data into a SQLite database that is empty prior to executing the app.

Figure 8: Desktop App Functionality

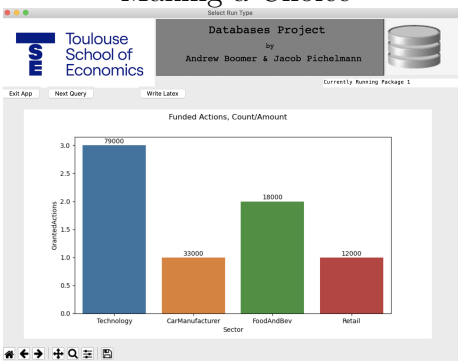
Filling the DB 1



Making a Choice



Query Results



Generating a Plot

More technically versatile users can also access the SQLite data base directly and make use of the generated views and stored queries. To this end we saved the filled database with all data points and executed queries in the data folder under the name *FilledDB.db*.

Data Sources

Airbus: `https://www.airbus.com/company/sustainability/reporting-and-performance-data.html`

Alphabet: `https://www.gstatic.com/gumdrop/sustainability/google-2019-environmental-rep pdf`

Apple: `https://www.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2019.pdf`

Siemens: `https://assets.new.siemens.com/siemens/assets/api/uuid:16c327d3-3e02-427e-952 siemens-sustainability-information-2019.pdf`

Snapchat: https://citizen.snap.com/products

Spotify: http://q4live.s22.clientfiles.s3-website-us-east-1.amazonaws.com/540910603/files/doc_downloads/govDocs/2019/03/2018-Spotify-Sustainability-Report-FINAL.pdf

Starbucks: https://www.starbucks.com/responsibility/global-report

Tesla: https://www.tesla.com/ns_videos/2019-tesla-impact-report.pdf

Total SE: https://www.sustainable-performance.total.com/en/reporting/our-csr-reports

Volkswagen: https://www.volkswagenag.com/de/sustainability/reporting.html

Walmart: https://corporate.walmart.com/global-responsibility/sustainability/