Database for the European Union Transaction Log

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Abstract

The European Union Transaction Log (EUTL) is the central reporting and monitoring tool of the European Emissions Trading System (EUETS), the world's largest emissions trading system. Through the EUTL, the European Commission publicly provides information on compliance of regulated entities, participants active in the system, and transactions between these participants. Accessing the data is rather burdensome as data access is inconvenient and, more important, the relation between different elements of the EUTL is missing. Out of the data publicly provided by the European Commission, I construct a relational database connecting the different elements of the EUTL facilitating the analysis of compliance and transaction behavior in the world's largest carbon market. These data can be assessed online on EUETS.INFO.

Updates

- 06.1.2024
  - Database update to include transaction data until 9/2021.
  - About 111'000 transactions have been in the data in the previous release. Data from the Union registry page however do not include these transaction anymore. Also at the EUTL page these transactions are now mission. These missing transaction have been included from the previous release.
- 06.08.2024
  - Inclusion of maritime operator accounts. Correspondingly, the field list of the installation table has been extended.
  - Inclusion of account identifiers that are used in the transaction data on the EUTL page.
  - Since 2022 the transaction data were missing a lot of acquiring accounts and some transferring accounts in the data provided by the European Commission. In the 2021 data, this information was still available. We inserted

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the missing account information from the 2021 dataset into the most recent (and future) version.

- 11.05.2024
  - Database update to include transaction data up to and including September 2019 and compliance data up to 2023.
- 09.05.2023
  - Database update to include transaction data up to and including April 2019 and compliance data up to 2022.
  - Version corresponds to the EUTL version *Version: 13.10.1EUTLP04-04-2023 15:05*
  - Added Effort Sharing Data
  - Inclusion of identifiers for the Orbis Database
- 26.05.20212
  - Database update to include transaction data up to and including April 2019 and compliance data up to 2022.
  - Version corresponds to the EUTL version *Version: 13.7EUTLP04-03-2022 14:52*
  - Transaction data are no longer parsed from downloaded transaction blocks but rely on transaction data made public by the commission (also see: Union Registry Page).
  - Due to link with the Swiss system, compliance, surrendering, and entitlement data might included assignments over the Swiss registry (for aircraft operators). To account for this entitlements are now reported as *euEntitlements* and *chEntitlements* in the installations table. Field *reportedInSystem* indicates the system in which data are reported (EUETS or CHETS) in the compliance and surrendering table. The field is part of the composite primary key.
  - Added additional fields to account holder table relating to phone number, mail address, and legal identifier of primary contact.
- 21.05.2021
  - Database update to include transaction data up to and including April 2018 and compliance data up to 2020.
  - Version corresponds to the EUTL version *13.1.1EUTLP23-04-2021 16:52*
  - Transaction data checked for consistency with transaction data made public by the commission (also see: Union Registry Page). Data published on the Union Registry page are consistent with the data provided by the EUTL except some transaction for the Luxembourg registry are mission in the data

published on the Commission page. Transaction blocks are sometimes inconsistent with amounts provided in the transaction overview (about 6300 transactions). In that case data from the Union Registry page are substituted for transaction blocks ensuring consistency between datasets.

1. Introduction

The European Union Transaction Log (EUTL) is the central reporting tool of the European Emissions Trading System (EUETS). The EUETS allows trading emission allowances between participants in the system. With a delay of three years, transactions are reported through the EUTL. The EUTL also offers detailed information on the compliance of each installation covered by the EUETS.

This note describes the construction of a database rebuilding the EUTL. The EUTL data can be downloaded from the EUTL webpage.[2] The original EUTL page poses two major challenges. First, it is difficult to relate the different bits and pieces, in particular, we are not able to relate accounts, installations, and their transactions. Second, the data is not accessible in a user friendly way. The major aim of this project is to provide a structured way to assess the EUTL information. To achieve this goal, I relate the different pieces of information in the EUTL; and I develop and store the information in a relational database model.

The construction of the database requires three steps:

1. *Download, parse, clean data*
   I download websites containing the EUTL data. Parsing the pages, I use links to reconstruct relations between the different components of the EUTL. In addition, I impose some satellite data including economic activities in the form of NACE codes and locations of installations.

2. *Restoring former operator holding accounts*
   In 2012/2013 the Community Independent Transaction Log was transformed into the EUTL. From the data side, the most notable change was the change in the account classification system. All *former operator holding accounts*, i.e. accounts related to installations, had to close and re-open as *operator holding accounts*. As the EUTL is static in the sense that it only reports the relation between installations and accounts for a given point in time, I develop an algorithm to reconstruct the historical relation between installations and former operator holding accounts. This relation is important to analyze the transaction behavior of installations before 2013.

3. *Development and implementation of data model*
   Provided processed EUTL data, I develop and implement a relational database model.

I describe step one and two in greater detail in Appendix A and B. In the description of these steps, I will be non-technical in the sense that I describe the overall approach

[2] https://ec.europa.eu/clima/ets/

but not every technical detail of, e.g., data parsing and cleaning. Moreover, I do not add on the programmatic implementation using Python. In the main text I concentrate on the information provided in the EUTL database and the implemented data model.

How to use the final database? The database can be assessed in two different ways: The website EUETS.INFO allows assessing the data online and, in addition, provides all data in csv format. On the website is possible to search for installations, accounts, and account holders using their names and then inspect the compliance and transaction behavior. Whereas the website also allows aggregating compliance data on the country level, it is not fully flexible and does not include every feature included in the underlying dataset.

Downloading and using the source data files is naturally the more complete but also more burdensome way of analyzing the dataset. To lower this burden, I started to develop a series of Python routines to implement the data model in Postgres SQL. This includes routines to create the database as well as an object relational mapper (ORM) to assess the data in a more convenient way. These routines are under active development and the latest versions are available on GitHub.[3]

In the remainder of this paper, I first provide a short primer on the EUTL explaining its different components and their relation. I then describe the information provided for each of these components. The relational data model is described in Section 4.

2. The European Union Transaction Log

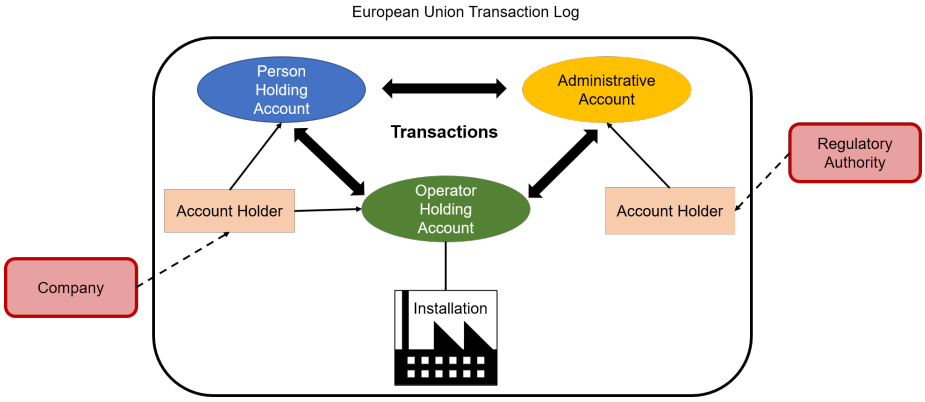
The EUETS regulates greenhouse gas emissions of stationary installations and airplanes. Every year, each installation[4] has to surrender allowances at least equal to its verified emissions of the previous year to the regulatory authority. Installations receive these allowances either by free allocation or buy them on the allowances market, e.g., in an auction or from another market participant. The EUETS is an open system, i.e., not only regulated entities and regulators but also non-regulated companies and actors are allowed to transfer allowances.

To make the trading of allowances possible, a system to account and transfer allowances between different actors is necessary. In the case of the EUETS this is the EUTL or formerly the CITL. Together with the EUTL, the EUETS introduces several building blocks (Figure 1). *Installations* are regulated entities. The obligation to surrender allowances for verified emissions as well as emission accounting takes place at the installation level. *Transactions*, i.e., the transfer of allowances between actors in the EUETS, takes place at the level of *accounts*. To be able to receive, transfer, and surrender allowances each installations is represented by an *operator holding account* (OHA). Likewise, to be able to allocate and receive surrendered allowances, regulatory authorities also have to be represented by accounts. I call these accounts *administrative accounts* (AA). Non-regulated actors (e.g. intermediaries) can join the system using *person holding accounts* (PHA). For each account, the EUTL provides a primary contact, which I call *Account Holder*.

[3] https://github.com/jabrell/eutl_orm

[4] I use the term installation to cover both, stationary installations as well as airplanes.

FIGURE 1. Structure of the European Union Transaction Log (EUTL)



In the analysis of the EUTL, account holders have a somewhat special role. The EUTL provides information on transactions between accounts represented by account holders. However, companies and regulatory authorities are not directly represented within the EUTL but through the account holder. Thus, account holders provide the link across the boundary of the EUTL (black box in Figure 1).

3. Information in the EUTL Database

In this section, I describe the information provided for each of the components of the EUTL. Along that line, I also present the tables provided in the database together with a description of each of the fields. Appendix C provides lookup tables, i.e., tables that include descriptions of activity, transaction, account etc.

3.1. Installations

The EUTL contains three types of information for installations. Details on the installation, on its compliance, and on the type and origin of surrendered units.

Each installation can be identified by a unique *id* that is constructed by the ISO2 code of the registry and the number of the installation in the registry (as provided by the EUTL webpage) (Table 1). Further information includes the registry in which the installation is registered. For stationary installations, the registry equals the country of location, aircraft operators are free to choose the registry.

Coverage of the installations under the EUETS is regulated on the activity level. If an installation performs an activity as listed in Table C.1, it falls under the EUETS.[5] Activities 1-9 and 99 have been introduced in 2005; the remaining activities in 2012. All classes are still used in the database. Given the large number of activities, it is often helpful to aggregate activity types. Table C.1 provides the aggregation used on EUETS.INFO.

[5]For a precise definition which activities are regulated refer to the Appendix of the EUETS directive.

We further observe the *entitlement* for international credit usage. The EUTL has a field to provide information on companies related to the installation. The information is however rarely provided.

In the case of stationary installations, the EUTL provides the address and location of the installation. Latitude and longitude provided are however rather incomplete and the quality does not seem to be very high. I thus use the address together with Google Maps API to retrieve a new set of locations.

I further include NACE codes of each installation based on the leakage assessment of the European Commission.[6]

For each installation, we observe compliance data including verified emissions, allocated and surrendered allowances for each year (Table 2). For allocations we observe whether allowances have been allocated for free or out of the new entry reserve or under Article 10c of the directive (includes 3f for aviation).

Compliance data are further detailed by details on surrendered units (Table 3) in particular the unit type (Table C.6). The information is particular valuable for the years before 2013. In these years we observe the country of origin and possibly the project identifier for international project mechanisms (Table 4).

3.2. Accounts

Each party participating in the EUETS is represented by an account. I distinguish three broad categories of accounts. *Operator Holding Accounts (OHA)*, *Person Holding Accounts (PHA)*, and *Administrative Accounts (AA)*. Table C.2 provides a mapping between the detailed account types used in the EUTL and these categories as well as the number of accounts by account type.

Each account is identifiable by a unique account *id*. Due to various processing steps, this *id* does not coincide with identifier used in the EUTL database. Together with the *name* of the account, we observe the account type and holder, when the account was opened/closed, and in case of an operator holding account the corresponding installation. The *companyRegistrationNumber* is useful to match accounts to firm level databases. The indicator *isRegisteredEutl* indicates whether the account is registered in the EUTL or in a registry outside the EUETS as, e.g., in the case of international project mechanisms.

The JRC matched company registration numbers to the Bureau van Dyke (BvD) Orbis database.[7]. We include these identifiers. In the orginal version of their matching, a company registration number is matched to multiple BvD identifiers. We establish a one-to-one matching by first choosing matches that also match on the location and second using the match with the highest matching score.

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[6] I include information from the NACE matching table of the 2020 leakage assessment (https://ec.europa.eu/clima/events/stakeholder-meeting-results-preliminary-carbon-leakage-list-phase-4-eu-emissions-trading_en) as well as from the 2015 assessment (https://ec.europa.eu/clima/sites/clima/files/installation_nace_rev2_matching_en.xls).

[7] Letout, Simon (2021): Firm level data in the EU ETS (JRC-EU ETS-FIRMS). European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/bdd1b71f-1bc8-4e65-8123-bbdd8981f116

TABLE 1. *installation.csv*: Installation table

Column	Type	Description
id	varchar	Installation id as combination of registry identifier and number unique in registry (e.g., AT_1)
name	varchar	Name of installation
tradingSystem	varchar	Trading system in which the installation is registered
registry_id	varchar	2-digit ISO code of registry
activity_id	int4	Key of installation activity
eprtrID	varchar	Identifier in the European Pollution Release and Transfer Register
parentCompany	varchar	Name of the parent company of the installation
subsidiaryCompany	varchar	Name of subsidiary company of the installation
permitID	varchar	Permit identifier of the installation
designatorICAO	varchar	Aircraft: Designator for the aircraft type according to the International Civil Aviation Organization
monitoringID	varchar	Aircraft: Identifier for monitoring plan to determine emissions of the aircraft operator
monitoringExpiry	varchar	Aircraft: Expiry date of monitoring
monitoringFirstYear	varchar	Aircraft: First year when monitoring plan becomes applicable
permitDateExpiry	timestamp	Date when permit identifier becomes invalid
isAircraftOperator	bool	Indicator whether the installation is an aircraft operator
isMaritimeOperator	bool	Indicator whether the installation is an maritime operator
ec748_2009Code	varchar	Aircraft: Identifier of aircraft operator under EC 748/2009 regulation (inclusion of aircrafts in the EUETS)
permitDateEntry	timestamp	Date when permit identifier was create
addressMain	varchar	Main address line of installation
addressSecondary	varchar	Secondary address line of installation
postalCode	varchar	Postal code of installation
city	varchar	City of installation
country_id	varchar	Country of installation
latitudeEutl	float8	Latitude as provided by EUTL
longitudeEutl	float8	Longitude as provided in EUTL
latitudeGoogle	float8	Latitude as derived by address from Google maps
longitudeGoogle	float8	Longitude as derived by address from Google maps
nace15_id	varchar	NACE code according to 2015 leakage list
nace20_id	varchar	NACE code according to 2020 leakage list
nace_id	varchar	NACE code according to 2020 leakage list with missing values filled from 2015 list
entitlement	int4	Entitlement for credits created from flexible mechanisms
chEntitlement	int4	Entitlement for credits created from flexible mechanisms created over Swiss registry.
euEntitlement	int4	Entitlement for credits created from flexible mechanisms created over EUTL
shippingCompany	varchar	Maritime only: Name of the shipping company
shippingCompanyType	varchar	Maritime only: Type of shipping company.
shippingCompanyCountry	varchar	Maritime only: Country of the shipping company.
imoID	varchar	Maritime only: Identifier of shipping company under the International Maritime Organization
region	varchar	Maritime only: Region of the shipping company

Notes: id is primary key. Foreign keys are marked by *_id*.

TABLE 2. *compliance.csv*: Compliance table

Column	Type	Description
installation_id	varchar	Unique ID of the related installation
year	int4	Year of compliance
reportedInSystem	varchar	System in which the data is reported (EUETS or CHETS)
euetsPhase	varchar	Phase of the EUETS
compliance_id	varchar	Compliance code
allocatedFree	int4	Number of certificates allocated for free
allocatedNewEntrance	int4	Number of certificates allocated out of the new entrance reserve
allocatedTotal	int4	Total number of allocated certificates
allocated10c	int4	Number of certificates allocated under Article 10 c of the EUTL directive, i.e., free allocation for modernization of electricity generation. For aviation this corresponds to allowances granted under article 3f.
verified	int4	Amount of verified emissions [t]
verifiedCummulative	int4	Cummulative amount of verfied emissions
verifiedUpdated	bool	Indicator whether verified emission have been updated ex-post
surrendered	int4	Number of surrendered certificates
surrenderedCummulative	int4	Cummulative amount of surrendered certificates

Notes: installation_id and *year* are used as composite primary key. Foreign keys are marked by *_id*.

TABLE 3. *surrender.csv*: Surrendering table

Column	Type	Description
id	serial	Surrendering identifier
installation_id	varchar	Installation identifier
year	int4	Year of surrendering
reportedInSystem	varchar	System in which the data is reported (EUETS or CHETS)
unitType_id	varchar	Identifier surrendered certificate type
amount	int4	Amount of surrendered units
originatingRegistry_id	varchar	2-letter iso code of country in which the certificate was created
project_id	int4	Identifier of project creating the certificate in case of flexible mechanism (CDM or JI)

Notes: id is the primary key. Foreign keys are marked by *_id*.

TABLE 4. *offset_project.csv*: Project table

Column	Type	Description
id	serial	Project identifier that also relates to UNFCCC database
track	int4	Track of the CDM project
country_id	varchar	Country in which the project takes place
source	varchar	Data source from which data are extracted

Notes: id is primary key. Foreign keys are marked by *_id*.

TABLE 5. *account.csv*: Account table

Column	Type	Description
id	serial	Unique account identifier
name	varchar	Name of account
accountIDEutl	varchar	Account identifier as used in the account data of the EUTL
accountIDTransactions	varchar	Account identifier as used in the transaction data of the EUTL
accountIDESD	varchar	Account identifier as used in the Effort Sharing data (composed of the valid year and the memberstate identifier)
yearValid	varchar	Only for ESD accounts: The year for which the ESD account is valid
tradingSystem	varchar	Trading system in which the account is registered
registry_id	varchar	2 letter ISO code for registry
accountHolder_id	int4	Identifier of account holder
accountType_id	varchar	Identifier of account type
isOpen	bool	Indicator whether the account is open
openingDate	timestamp	Indicator whether the account is open
closingDate	timestamp	Indicator whether the account is open
commitmentPeriod	varchar	Refer to Kyoto commitment period
companyRegistrationNumber	varchar	VAT registration number of the associated company
companyRegistrationNumberType	varchar	Type of the company registration number
isRegisteredEutl	bool	Account is registered in the EUTL
installation_id	varchar	Identifier of installation
bvdId	varchar	ORBIS identifier

Notes: id is primary key. Foreign keys are marked by *_id*.

3.3. Account Holders

Account holders are the primary contact of accounts. *id* provides the unique identifier for each account holder. We additionally observe the name as well as address of the account holder. Account holders prove in particular useful in matching with firm level data as the address often coincide with company addresses.

TABLE 6. *account_holder.csv*: Account holder table

Column	Type	Description
id	serial	Identifier of account holder
name	varchar	Name of account holder
tradingSystem	varchar	Trading system in which holder is active
addressMain	varchar	Primary address line
addressSecondary	varchar	Secondary address name
postalCode	varchar	Postal code
city	varchar	City name
country_id	varchar	2-digit ISO country identifier
telephone1	varchar	Phone number 1
telephone2	varchar	Phone number 1
eMail	varchar	E-mail address
legalEntityIdentifier	varchar	Legal identifier of primary contact

Notes: id is primary key. Foreign keys are marked by *_id*.

3.4. Transactions

Transactions take place between two accounts. Each transaction is classified using a main (Table C.4) and supplementary type (Table C.5). One transaction combines several transaction blocks which detail the type of allowances transferred (Table C.6).

To keep this information, data are extracted on the level to transaction blocks and finally aggregated again. As a consequence, the unique identifier of each transaction, *id*, does not coincide with the transaction identifier originally assigned by the EUTL. The transaction table (Table 7) provides the original identifier in the field *transactionID* that is, however, not unique in the provided database. Apart from involved accounts, transaction and unit types, we observe the date of the transaction and the amount of allowances transferred.

TABLE 7. *transaction.csv*: Transaction table

Column	Type	Description
id	serial	Unique ID of the transaction
transactionID	varchar	ID of the transaction in which the transaction block took place
tradingSystem	varchar	Trading system in which the transaction takes place
date	timestamp	Date of transaction
transactionTypeMain_id	int4	Main transaction type
transactionTypeSupplementary_id	int4	Supplementary transaction type
transferringAccount_id	int4	Identifier of account that transferred the permits
acquiringAccount_id	int4	Identifier of the account that aquired permits
unitType_id	varchar	Type of certificate transfered
project_id	int4	Identifier of the CDM or JI project that created the certificate
amount	int8	Number of units transferred

Notes: id is primary key. Foreign keys are marked by *_id*.

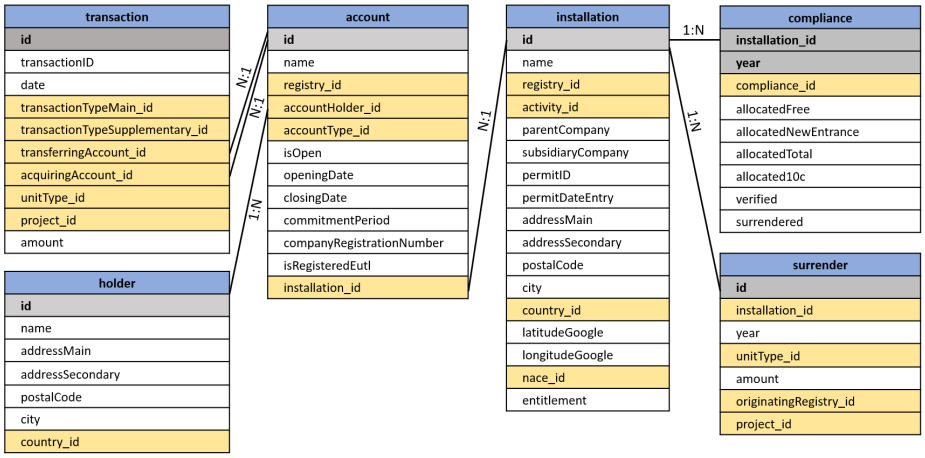
4. A Relational Model of the EUTL

Figure 2 shows the relations in the database among the core tables. Each Installation (right hand side) relates to N different entries in the compliance and surrendering. For compliance, we observe allocated and surrendered allowances, and verified emissions for each year the installation was part of the EUETS. For surrendering, each installation is related to a row in the surrendering table, characterized by the unit type and origin of the surrendered unit.

At each instance in time, each installation is associated with exactly one operator holding account. The OHA representing an installation might however change over time. An installation therefore might relate to N different OHAs. For most installations, we observe at least two associated accounts due to the 2012/13 reform of the EUTL causing most installations for be related to an former operator holding account (account type 120-0) and an operator holding account (100-7).

Each account relates to exactly one account holder. An account holder can be related to several accounts. This relation can be used to detect which accounts belong together. As an example, a large power company with several power plants, necessarily has to register several OHAs for its installations (one for each installation). Often the account holder is the same for all of these OHA. The company could then also be related to a PHA doing all of its trading activities over a central trading account. To detect such patterns, EUETS.INFO allows searching accounts by account holder. Also given a specific account, the website reports related accounts as accounts sharing the same account holder.

FIGURE 2. Relations in the EUTL Database



Notes: The header of each box states the table name. Primary keys are provided in gray boxes and bold font. Foreign keys in orange-yellow boxes. Not all fields are shown. For a complete list of fields and description of their content consult the respective table.

A transaction relates to two accounts via the transferring and acquiring account identifier. The transferring account provides allowances that are transferred to the acquiring account. Each account can be involved in several transactions in both roles. E.g., OHAs are involved in at least two transactions in each year. OHAs need to acquire allowances to cover their verified emissions. To be compliant under the EUETS, OHA then need to surrender these units, i.e., are involved in a transaction as transferring account.

5. Conclusion

The EUTL provides a large amount of information on the world's largest carbon market, the EUETS. This includes information on compliance behavior, details on surrendered units, and allowances transfers between participants. This project aims to make this information more accessible. For this, I provide three complementary resources:

- **EUETS.INFO** provides high-level access to the data. It allows assessing compliance data by installation and find the associated accounts. These data are also provided on an aggregated level by country. Accounts can also be assessed using account names, holders, and types. For each account or account holder, it provides transactions.
- **Source data** The compiled database is available for download on the website. All tables are provided in csv format.
- **Python routines** On GitHub I provide some routines to create a SQL database implementing the data model. The repository also provides a first implementa-

tion of an object relation mapper (ORM) to access the created database. These steps are explained in a series of Jupyter notebooks.

For exploratory data analysis, these resources work best in conjunction. I suggest downloading the source data and using the GitHub routine to create a local database. Then using the python routines, start analyzing a single installation. The GitHub repository shows a first example. The most easy way to find an account or installation identifier is using the website. If you start analyzing, e.g., transactions, you can always use the page to get additional information about accounts or account holders.

Appendix

A. Data Download and Extraction

The EUTL data can be downloaded from the EUTL webpage.[8] Two ways of data download are possible: First, the EUTL offers the possibility to download the data in XML format. Second, all data displayed on the webpage can be downloaded and the information can be extracted afterwards.

The XML approach has the drawback that export is limited to 3000 data points. Moreover, at the time I tested the XML approach, it seemed that information was less complete. Most importantly, the XML approach makes it rather complicated to connect the bits and pieces of the EUTL. In contrast, using a crawler downloading each single website allows reconstructing the connection between transactions and accounts using information hidden in the html code.

The strategy of the webcrawler is the same in all cases, I first fetch the overview pages and then follow the links provided to download the corresponding sub pages. The process is rather time consuming in particular for the transaction data.[9]

A.1. Account Data

For the account data, I download the overview over all accounts from the EUTL page.[10] For each account, this overview contains the account holder name, address, the account type, and a link to the website containing the details for the account. This link contains a query that includes an account ID that is unique in the whole registry. I thus, extract the account ID out of the provided link and use this ID to query the details for each account.[11] In this way, I download the details for each account and also create the unique account ID. Out of the account data, I construct two tables: The account and account holder table.

In the original data, each account is associated with one account holder. I remove duplicated account holders. A duplicate is defined in terms of the name and address of the account holder.[12] I then re-establish the relation between accounts and account holders. After the deletion of duplicated account holders, one account holder possibly relates to several accounts. This might be interpreted as the one account holder being the representative of a company that owns multiple accounts.

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[8] https://ec.europa.eu/clima/ets/

[9] Downloaded pages as well as intermediate files containing the content of parsed pages are available on request.

[10] I.e., I get all pages created under the query: https://ec.europa.eu/clima/ets/account.do?languageCode=en&accountHolder=&search=Search&searchType=account&currentSortSettings=

[11] E.g., https://ec.europa.eu/environment/ets/singleAccount.do?accountID=5812&action=details&languageCode=en&registryCode=DE provides the account ID 5812 and the link to the details of this account. Importantly, albeit the account ID is unique in the registry, it is not sufficient to perform a query but needs to be combined with the code for the registry in which the account is registered (in the show case "DE" for Germany).

[12] Duplicate elimination requires that this information is provided. If one of the fields is not present, I do not delete the duplicates. This is a rather conservative approach allowing for further improvements.

A.2. Installation Data

Given the account ID of OHA and the corresponding registry, I download installation details including compliance data.[13] In the same manner, I download compliance details and details about surrendering units.[14] I also download pages containing the entitlement for offset usage of each installation.[15] The installation identifier provided by the EUTL is not unique but unique within a registry. I construct a unique ID combining the ID with the registry codes.[16] I construct four tables out of the installation pages: Installation details, compliance, surrendering details, and offset projects[17].

Given the extracted installation tables, I impose additional information in the form of latitude and longitude of stationary installations and the economic activity of the installation (see Section 3.1).

A.3. Transaction Data

To download transaction data, I first get all pages for the transaction overview.[18] Each entry in this overview provides a link to the corresponding transaction details containing all transaction blocks together with the unit type. Most important, the details provide a link to accounts involved (as long as they are registered in the EUTL). Albeit unique, the account identifier used in this link does not coincide with the one provided in the account data. I thus follow the link. The corresponding account identifier as reported in the account data is then stored in a hidden field in the html code of the landing page. Following all links in the transaction data, I construct a correspondence between the account identifier used in the account and transaction data and, the missing link between transaction and account data. Out of the downloaded transaction detail pages, I construct a table with transaction blocks, containing the transferring and acquiring account identifier, the transaction date, the amount and type of units transferred, as well as the transaction type. In case of international credits, the code extracts the information about the offset project and inserts them into the project table.

International transactions might involve accounts that are not registered in the EU-ETS but in another registry. For these accounts, we do not observe data on the account websites of the EUTL. However, transactions often provide the name and country of these accounts and also an identifier which seems to be unique. For these accounts, I

[13] E.g., https://ec.europa.eu/clima/ets/ohaDetails.do?accountID=103550&action=all&registryCode=DE

[14] E.g., https://ec.europa.eu/clima/ets/surrenderedUnits.do?accountID=103550&registryCode=DE&action=surrenderedDetails&installationID=76601&returnURL=&periodCode=0

[15] https://ec.europa.eu/clima/ets/ice.do?languageCode=en&registryCode=-1&accountFullTypeCode=-1&iceInstallationId=&search=Search&currentSortSettings=

[16] E.g., I assign the identifier AT_1 to installation 1 in Austria (AT).

[17] Offset projects are also reported in the transaction data. I also include these projects into the table.

[18] https://ec.europa.eu/clima/ets/transaction.do?languageCode=en&startDate=&endDate=&transactionStatus=4&fromCompletionDate=&toCompletionDate=&transactionID=&transactionType=-1&suppTransactionType=-1&originatingRegistry=-1&destinationRegistry=-1&originatingAccountType=-1&destinationAccountType=-1&originatingAccountIdentifier=&destinationAccountIdentifier=&originatingAccountHolder=&destinationAccountHolder=&search=Search&currentSortSettings=

therefore construct additional accounts populated from the information provided in the transaction data.

A.4. Compiling the final database

Most of the tables extracted out of the downloaded pages can be used directly. Besides cleaning tables from unnecessary fields and ensuring consistent data types, two major modifications are provided in the database constructions. First, I reconstruct the the relation of installations and former operator holding accounts (see Section B). Second, to reduce the size of the transaction table, I group transaction blocks by date, involved accounts, the original transaction identifier, and unit and transaction type information.

B. Reconstructing Former Operator Holding Accounts

Due to the reform of the EUTL in 2012/13 former OHAs (account type 120-0) had to close and re-open as OHAs (account type 100-7). For (most) former OHAs (fOHAs) the link to the respective installation is therefore missing. To be able to analyze the transaction behavior of installations over time, I reconstruct the relation of fOHA and installations using account holders and transaction data. This matching is performed in three steps:

1. Matching by name and account holder: For all fOHA I search in the account table whether I find an active OHA that has (a) the same account name and (b) the same account holder. Only unique matches are accepted.

2. Matching by surrendering transfers: I search for surrendering transfers of the fOHA by filtering transactions on the acquiring account type to be a party holding account (100-0)[19] and the supplementary transaction type indicating a surrendering transfer (supplementary type 2). Aggregating these transaction (blocks) by year, I search the compliance table for installations in the same registry and with surrendering data equal to the transferred amount out of the transaction data. In this step, I accept matches in which surrendering transfers match at least 75% of surrendering amounts provided in the compliance table.

3. Matching by allocating transactions: This follows the same logic as with the surrendering transactions but party holding accounts being on the transferring side and the supplementary transaction type indicating an allocation (supplementary type 53).

In total 12814 out of 13016 fOHAs are matched to installations. Most fOHAs are matched by name and account holder (9085), followed by surrendering (3590) and acquiring transfers (139).

C. Lookup tables

[19] Until 2012, compliance took place at the member state level.

TABLE C.1. *activity_type.csv*: Activities regulated under the EUETS

id	description	category
1	Combustion installations with a rated thermal input exceeding 20 MW	Combustion
2	Mineral oil refineries	Refineries
3	Coke ovens	Coke ovens
4	Metal ore (including sulphide ore) roasting or sintering installations	Metal
5	Installations for the production of pig iron or steel (primary or secondary fusion) including continuous casting	Metal
6	Installations for the production of cement clinker in rotary kilns or lime in rotary kilns or in other furnaces	Cement and Lime
7	Installations for the manufacture of glass including glass fibre	Glass and Ceramics
8	Installations for the manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain	Glass and Ceramics
9	Industrial plants for the production of (a) pulp from timber or other fibrous materials (b) paper and board	Pulp and Paper
10	Aircraft operator activities	Aircrafts
20	Combustion of fuels	Combustion
21	Refining of mineral oil	Refineries
22	Production of coke	Coke ovens
23	Metal ore roasting or sintering	Metal
24	Production of pig iron or steel	Metal
25	Production or processing of ferrous metals	Metal
26	Production of primary aluminium	Metal
27	Production of secondary aluminium	Metal
28	Production or processing of non-ferrous metals	Metal
29	Production of cement clinker	Cement and Lime
30	Production of lime, or calcination of dolomite/magnesite	Cement and Lime
31	Manufacture of glass	Glass and Ceramics
32	Manufacture of ceramics	Glass and Ceramics
33	Manufacture of mineral wool	Glass and Ceramics
34	Production or processing of gypsum or plasterboard	Glass and Ceramics
35	Production of pulp	Pulp and Paper
36	Production of paper or cardboard	Pulp and Paper
37	Production of carbon black	Chemicals
38	Production of nitric acid	Chemicals
39	Production of adipic acid	Chemicals
40	Production of glyoxal and glyoxylic acid	Chemicals
41	Production of ammonia	Chemicals
42	Production of bulk chemicals	Chemicals
43	Production of hydrogen and synthesis gas	Hydrogen Production
44	Production of soda ash and sodium bicarbonate	Chemicals
45	Capture of greenhouse gases under Directive 2009/31/EC	Carbon Capture and Storage
46	Transport of greenhouse gases under Directive 2009/31/EC	Carbon Capture and Storage
47	Storage of greenhouse gases under Directive 2009/31/EC	Carbon Capture and Storage
50	Maritime operator activity	Maritime
99	Other activity opted-in pursuant to Article 24 of Directive 2003/87/EC	Other
1000	Member state activity for Effort Sharing Accounting	

Notes: Activity codes (id) and desciption extracted from EUTL webpages. *Categories* are categories as used on EUTL.INFO but not provided in the distributed csv file.

TABLE C.2. *account_type.csv*: Account Types in the EUTL

id	description
Operator Holding Accounts	
100-7	Operator Holding Account
100-9	Aircraft Operator Account
120-0	Former Operator Holding Account
Person holding accounts	
100-8	Person Holding Account
100-12	Trading Account
121-0	Person Account in National Registry
Administrative Accounts	
0-10	Verifier Account
0-11	External Platform Holding Account
100-0	Party Holding Account
100-1	AAU Deposit Account
100-2	National Allowance Holding Account
100-3	Central Clearing Account
100-4	Gateway Deposit Account
100-5	Union Allowance Deletion Account
100-6	Aviation Surrender Set-Aside Account
100-13	Auction Delivery Account
100-14	Auction Account
100-15	Aviation Auction Account
100-16	Total Quantity Account
100-17	Aviation Total Quantity Account
100-18	New Entrant Reserve Account
100-19	Special Reserve Account
100-20	Allocation Account
100-21	Aviation Allocation Account
100-22	International Credit Account
100-23	Credit Exchange Account
100-24	AEA Total quantity Account
100-25	ESD Compliance Account
100-26	AEA Deletion Account
100-27	EU AAU Account
100-28	ETS AAU Deposit Account
100-29	ESD Central Clearing Account
100-30	ESD AAU Deposit Account
100-31	ETS Central Clearing Account for CP2
110-0	Pending Account
130-0	Previous Period Surplus Reserve Account (PPSR)
210-0	Net Source Cancellation Account (Type 1)
220-0	Non-compliance Cancellation Account (Type 2)
230-0	Voluntary Cancellation Account (Type 3)
240-0	Excess Issuance Cancellation Account (Type 4)
241-0	CCS Net Reversal Cancellation Account
242-0	Non Submission Of Verification Report Cancellation Account
250-0	Mandatory (Cancellation Account (Type 5)
270-0	Article 3.7ter Cancellation Account (Type 7)
280-0	Ambition Increase Cancellation Account (Type 8)
300-0	Retirement Account
411-0	tCER Replacement Account for Expiry (Type 1)
421-0	lCER Replacement Account for Expiry (Type 1)
422-0	lCER Replacement Account for Reversal in Storage (Type 2)
423-0	lCER Replacement Account for Non-submission of Certification Report (Type 3)

Notes: Account codes (id) and descriptions are extracted from EUTL webpages. Account types not listed there are, thus, not included in the table.

TABLE C.3. *compliance_code.csv*: Compliance Codes

id	description
A	The number of allowances and ERUs/CERs surrendered by 30 April is greater than or equal to verified emissions
B	The number of allowances and ERUs/CERs surrendered by 30 April is lower than verified emissions
C	Verified emissions were not entered until 30 April
D	Verified emissions were corrected by competent authority after 30 April of year X. The competent authority of the Member State decided that the installation is not in compliance for year X-1
E	Verified emissions were corrected by competent authority after 30 April of year X. The competent authority of the Member State decided that the installation is in compliance for year X-1
X	Entering verified emissions and/or surrendering was impossible until 30 April due to the allowance surrender process and/or verified emissions update process being suspended for the Member State's registry
-	No Compliance Obligations

Notes: Compliance codes (id) as extracted from the EUTL.

TABLE C.4. *transaction_type_main.csv*: Main Transaction Types in the EUTL

id	description
1	Issuance - Initial creation of a unit
2	Conversion - Transformation of unit to create an ERU
3	External - External transfer of unit between registries
4	Cancellation - Internal transfer of unit
5	Retirement - Internal transfer of unit
6	Replacement - Internal transfer of unit
7	Carry-over - Change of validity to subsequent CP
8	Expiry Date Change
10	Internal - Internal transfer of unit/supplementary program transaction

Notes: Transaction codes (id) as extracted from the EUTL.

TABLE C.5. *transaction_type_supplementary.csv*: Supplementary Transaction Types in the EUTL

id	description	id	description
0	No Supplementary Type	52	Allowance issue (2008-2012 onwards)
1	Allowance cancellation (2005-2007)	53	Allowance allocation
2	Allowance surrender	54	Force-majeure allowance issue
3	Retirement (2005-2007)	55	Correction to allowances
4	Surrender Kyoto Units from AOHA	56	Conversion prior to Transfer to SOP (Conversion A)
12	ESD KP Transfer from PHA	57	Conversion of AAUs or RMUs into ERUs (Conversion B)
16	ESD Return to KP after Compliance	61	Surrendered Allowance Conversion
19	Retirement ESD Used Units	62	Unallocated Allowance Conversion
21	External transfer (2005-2007)	71	Exchange
22	External transfer between art63a registries	72	Exchanged
24	Issuance - Internal transfer Art 63a	75	75-AAU set aside
26	Conversion of art63a allowances	82	Reversal of surrender
30	Issuance of aviation allowances	84	Reversal of Surrender Kyoto Units from AOHA
31	Issuance of general allowances	86	Reverse of Excess Allocation
33	Aviation allowances - Banking	90	Deletion of allowances
34	General allowances - Banking	91	Cancellation against deletion
35	Allocation of aviation allowances	92	Reversal of Allowance Surrender
36	Allocation of general allowances	93	Correction
37	Auction delivery	94	Reversal of Allowance Cancellation
38	Carry Over of CERs or ERUs converted from AAUs	104	Reversal of cancellation
39	Carry Over of AAUs	124	Reversal of cancellation
41	Cancellation and replacement	135	Allocation of aviation allowances
42	Transfer Entitlement	136	Allocation of general allowances
43	Carry Over Entitlement	142	Reversal Transfer Entitlement
44	ESD Reversal KP Transfer	143	Reversal Carry Over Entitlement
45	Article 3.7ter Cancellation	171	Reversal of Exchange
46	Ambition Increase Cancellation	172	Reversal of Transfer of Exchanged
47	Transfer to SOP for First External Transfer of AAUs	190	Reversal of deletion
48	Mandatory Cancellation	272	Reversal of Issuance of Exchanged
49	Transfer to SOP for Conversion	272	Reversal of Issuance of Exchanged
51	Allowance issue (2005-2007)		

Notes: Transaction codes (id) as extracted from the EUTL.

TABLE C.6. *unit_types.csv*: Types of allowances

id	description
RMU	RMU - Removal Unit
CER	CER - Certified Emission Reduction Unit
ERU_RMU	ERU - Emission Reduction Unit (Converted from an RMU)
tCER	tCER - Temporary CER
EUA_2013	General allowances
EUA_2008	AAU - Assigned Amount Unit - Allowance issued for the 2008-2012 period and subsequent 5-year periods and is converted from an AAU
ERU	ERU - Emission Reduction Unit (Converted from an AAU)
EUA2005	Allowance issued for the 2005-2007 period and not converted from an AAU or other Kyoto unit
AEUA	Aviation allowances
AAU	AAU - Assigned Amount Unit

Notes: Description extracted from EUTL webpage, own codes (id) imposed.