Trade, Outsourcing, and the Environment

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This file explains how to replicate the analysis for the paper "Trade, Outsourcing, and the Environment"

Replication

Introduction

This replication package consist of three parts: datamanipulation, model_analysis and plotting_output. They have to be run in this order to 1. Manipulate the raw data for the model analysis 2. Do the model analysis and export results in cvs form 3. Plot the results based on the csvs for the paper (3 separate files)

Prior to running the replication script please download the required raw data from about ten different sources. We only use publicly available data easily accessible following the instructions we provide in DATA_OVERVIEW.txt. We provide some of the raw data that does not have any restriction on distribution (such as World Bank and Federal Reserve System data).

License for Code

The code is licensed under a Creative Commons license. See LICENSE for details.

Computational requirements

Software Requirements • Stata (used version 16) • Matlab (used version 2023b with Statistics and Optimization Toolboxes) • R (used version 4.3.0)

Memory and Runtime Requirements • The code was last run on a Windows 10 laptop with 16GB of RAM and i5-1145G7 processor @2.60GHz. • All scripts take about 60 minutes to run in total.

Detailed Instrunctions

Data manipulation

The data preparation is done in two parts, which is split over the folders manipulation and analysis. For replication, one only needs to run the file Step1_run_R_script.R; and one thus requires R. In the manipulation folder, first all the raw IO tables are aligned into one sector structure, both for WIOD and EORA. The same is done for emissions and VA data. Then the WIOD RoW category is split into the EORA countries. The number of countries used for this can be chosen.

In the analysis folder, the manipulated IO data is then prepared for the Matlab code and some summary statistics are produced.

If one wants to adjust the settings and run the data preparation separately, then in both folders, one only needs to run one file and change the path on the top of that file. If one wants to adjust some assumptions or thresholds, this can be done at the top of both main files.

Manipulation folder

- datamanip_main Runs all the subsequent files to give you the data needed for analysis –> Only file you need to run. If you run it the first time chose first_run=1, otherwise only need to adjust path on top of file. If you only want to adjust wiod_eora (country threshold in EORA), then chose smth else there. All the following files in this folder are called on by this file.

- adjust_wiod Read in WIOD data, adjust to new sectoral classification Also add emissions data (convert to million tons) and tax revenue from energy and CC related taxes

- adjust_eora Read in EORA (data here comes from different files) and also adjust to new sector classification.

- e_price_calculation Creates dataframes per country and sector, containing the costs of emissions. Based on WIOD and EORA emissions/energy usage data and OECD/IEA prices. These prices are incorporated manually, and currently not country specific.

- Wiod_eora Aimed at splitting the rest of the World in WIOD in as many countries from EORA as desired.

1. Keep only EORA countries larger than X, put the rest into ROW sector
2. Take only IO part(including final_use) and determine each countries share on total column and row Use this to split the WIOT ROW columns and rows into the EORA countries. The final s thus based on the value in WIOD and the share of each country in EORA
3. Do the same for emissions and VA
4. Keep respective countries in tax and emission costs data(latter is from e_price_calculation)

Mappings subfolder (called on automatically)

- sector_mapping: Just contains vectors that are used to map from one sector classification to another

- christea_mappings Used to create the transport emissions Needed to split regions in their data into our countries

- neighboring_countries Also used to create transport emissions Needed to get estimate of within country mode shares and weight to value ratios

- Country groupings Used to rwturn the indices of countries in certain groups. Can be used in Matlab tor example to simulate shock in these groups.

Analysis folder

- analysis_main Main file –>Only one you need to run here. Takes data, creates all parameters and exports all the parameters in csv format for the modelling Reads in individual files from subfolder that each creates a parameter Also runs the following two files.

- summary_table Creates summary statistics used in the paper. Included in analysis_main

- env_taxes Uses the Eurostat environmental tax data to get rid of the household (hh) part in OECD data and uses the industry split in Eurostat to split the OECD data into industries. Included in analysis_main. Needs to run first there.

Model analysis

Here you find all the files needed for the actual model analysis under the folder "model_analysis" You only need to run the Step2_run_matlab_script.m file. This step requires Matlab (R2018b or later) with statistics and optimization toolboxes. It first calibrates the model using outputs from the previous scripts and then runs the simulations. The script takes about 15 minutes on an average laptop in 2023 (Intel i5 Gen 10, 16GB RAM, Windows 11).

Relevant folders: data/output_mat_wiod_eora –> location of data generated by R scripts data/data_mat –> data converted into matlab format to be read by the simulation script data/results –> results in matlab format data/results_csv –> results in csv format

Important files: Climate_v7_RUN.m –> main simulation script Create_data.m –> calibration script, converts data to matlab format under data/data_mat Export_csv_results –> exports results in csv format Solve_EK.m –> main function solving the model

Auxiliary files: objf.m, obj_disutilit2.m, objf_solve.m, objf_diff –> functions used to take numerical derivatives and perform intermediate operations

All files currently use the calibrations presented in the paper.

Plotting output

The plotting output folder plots the results from the Matlab analysis. You can find all the three necessary files in the folder Step3_plotting_output

- Step3_a_chorplot.R Plots the circlized diagrams representing changes in traded emissions Just need to choose folder structure on top and it will produce both plots. Requires R.

maps (Stata files) Two files. - Step3_b_maps_rep_csv.do Creates the CSVs on which the maps in the paper (and more) are based on. Does not create the final maps, as these are done by a cartographic unit within the bank Just need to choose folder structure on top and it will produce all results

- Step3_b_maps_rep_wmaps.do Created the maps from the paper (and some more). However, these do not look like the ones in the paper as those are made by the cartographic unit within the World Bank.

- Step3_c_bar_plots.m Plots the level changes in emissions and transportation; requires Matlab again.

Data Availability Statement

We list the raw data sources here. We describe where one can download the data, and under which names they are called in. We use this raw data to extract the data needed for the model simulations. We keep the folder structure in data/raw, to make it easier for a full replication.

We do not provide raw data here, as we do not have the necessary license to do so. We only provide list with country mappings, needed for the output plotting, as well as map shape files.

WIOD

We use the World Input Output data, compiled by the university of Groningen. We use the 2016 release and the "WIOT tables in R" as well as the Environmental Satelite accounts, both downloadable from: https://www.rug.nl/ggdc/valuechain/wiod/wiod-2016-release (https://www.rug.nl/ggdc/valuechain/wiod/wiod-2016-release). We did not adjust the file names, and one needs to unpack the folders AIR and EM into the same folder as the IO data. The files should be placed under "/data/raw/WIOTS_in_R".

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015), "An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production" ,

EORA

We use the EORA 26 basic prices version from 2009, available on: https://worldmrio.com/eora26/ (https://worldmrio.com/eora26/) (one needs to create a free account to download the data) We do not adjust the file names. The data should be placed under "data/raw/EORA26_2009"

OECD tax data

One can download the environmental tax data from: https://stats.oecd.org/Index.aspx?DataSetCode=ERTR (https://stats.oecd.org/Index.aspx?DataSetCode=ERTR) Our file is named "ERTR_31012023222956399.csv" and one can download the whole file. The R script picks the respective tax type that is needed. The data

should be placed under "data/raw/OECD/env_tax_rev/"

OECD exchange rate data

We use the OECD exchange rates towards the US dollar, which can be downloaded from: https://data.oecd.org/conversion/exchange-rates.htm (https://data.oecd.org/conversion/exchange-rates.htm)

We rename the file to "x_rates.csv". The data should be placed under "data/raw/OECD/x_rates/".

Trade and the greenhouse gas emissions from international freight transport

#replication package

We use data from their replication package, which can be downloaded from David Hummel's website: https://business.purdue.edu/faculty/hummelsd/research/datasets.php (https://business.purdue.edu/faculty/hummelsd/research/datasets.php)

We do not rename any of their files and save them in the folder "data/raw/christea_et_al/".

Cristea, A., Hummels, D., Puzzello, L., & Avetisyan, M. (2013). Trade and the greenhouse gas emissions from international freight transport. Journal of environmental economics and management, 65(1), 153-173.

Trade barriers and CO2 replication package

We use data from their replication package, which can be downloaded from: https://data.mendeley.com/datasets/m2tz6xvtzg/1 (https://data.mendeley.com/datasets/m2tz6xvtzg/1)

We save the files under "data/raw/trade_boundaries_rep" and do not change the file names.

Klotz, R., & Sharma, R. R. (2023). Trade barriers and CO2. Journal of International Economics, 141, 103726.

IEA data

The R code does not call the IEA data, but we copied the needed values into the R file "e_price_calculation.R". The respective pdf report can be downloaded from: https://www.oecd.org/publications/energy-prices-and-taxes-for-oecd-countries-7b080c52-en.htm (https://www.oecd.org/publications/energy-prices-and-taxes-for-oecd-countries-7b080c52-en.htm) More information about which prices we chose can be found in our paper.

Eurostat emission tax revenue

The data can be downloaded from: https://ec.europa.eu/eurostat/databrowser/view/env_ac_tax/default/table?lang=en (https://ec.europa.eu/eurostat/databrowser/view/env_ac_tax/default/table?lang=en) We rename the file to: "env_ac_taxind2_linear.csv". The data should be placed under "data/raw/OECD/eurostat/".

FED CPI

We use the Consumer Price Index for All Urban Consumers: All Items in U.S. City Average It can be downloaded from: https://fred.stlouisfed.org/series/CPIAUCSL (https://fred.stlouisfed.org/series/CPIAUCSL). The data should be placed under "data/raw/OECD/FED/".

Country mappings for welfare analysis

For the welfare analysis, we need to split the estimates of: "Nordhaus, W. D., & Boyer, J. (2003). Warming the world: economic models of global warming. MIT press.", into the countries that we study in our paper. We do this manually and rely on table 3.1 in their paper. We save the mapping in a csv and a text file, which combine

the 3digit ISO code and the respective country grouping.

We use country codes from the gravity data from CEPII:
http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=8
(http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=8)

The files are under "raw/".

Map files

To create the maps used in the replication package (which are unequal to the ones in the paper), one can download the shape files from: https://datacatalog.worldbank.org/search/dataset/0038272 (https://datacatalog.worldbank.org/search/dataset/0038272)

We provide the mercator projection shape files in the raw data folder.

A good tutorial on how to make maps in Stata including on the used mercator projection can be found here: https://blogs.worldbank.org/impactevaluations/making-visually-appealing-maps-stata-guest-post-asjad-naqvi (https://blogs.worldbank.org/impactevaluations/making-visually-appealing-maps-stata-guest-post-asjad-naqvi)

The file should be placed under "raw/".

World Bank GDP data

We use GDP data from the World Development indicators from the World Bank. Available on https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.CD&country (https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.CD&country) The file is called "API_NY.GDP.PCAP.CD_DS2_en_csv_v2_4888903". We use the data in the R code, but currently not in the model. The files are under "/data/raw/WB_GDP_pc".

List of Exhibits

Overview of output and connection to figures and tables in draft We link the figures in the table to the output from the replication package here.

- Table 2: summary.tex under data/output/tables

All maps are under Step3_plotting_output, in different formatting as in the paper. The maps were not created by the authors, but by an independent cartographic unit in the World Bank based on the results of the paper, and slight discrepancies in the formatting are based on this. If one wants to check the results, the exact ones can be found in the csvs created by the respective Stata do file. If one leaves the Stata code untouched, the corresponding figures in the paper are saved under (in brackets the column name in the csv files): - Figure 1: Eintens0 (Eintens0)

- Figure 2: psi (psi)

- Figure 3: q_tax_Eintens and q_cbam_Eintens (q_Eintens_percentage; files _tax_base_q and _cbam_base_q)

- Figure 5: q_tax_Outsrc_fixY and q_cbam_Outsrc_fixY (Outsrc_fixY_percentage; files _tax_base_q and _cbam_base_q)

- Figure 6: q_tax_Abatement_fixY and q_cbam_Abatement_fixY (Abatement_fixY_percentage; files _tax_base_q and _cbam_base_q)

- Figure B1: p_tax_Welf and p_cbam_Welf (Welf_percentage; files _tax_base_p and _cbam_base_p)

- Figure D1: q_tax_Ytot and q_cbam_Ytot (Ytot_percentage; files _tax_base_q and _cbam_base_q)

- Figure D2: q_tax_Income and q_cbam_Income (Wageincome_percentage; files _tax_base_q and _cbam_base_q)

If one wants to create Figures E1 and E2, one needs to change the "elasticity_type" in the Stata do file to "fl" (as described there). The corresponding figures are then: - Figure E1: q_tax_Outsrc_fixY and q_cbam_Outsrc_fixY (Outsrc_fixY_percentage; files _tax_fl_q and _cbam_fl_q)

- Figure E2: q_tax_Abatement_fixY and q_cbam_Abatement_fixY (Abatement_fixY_percentage; files _tax_fl_q and _fl_base_q)

(As this code is only for replication purposes and not used in the paper, we do no save base and fl figures seperately. One can easily do so if desired.)

- Figure 4: both panels are under Step3_plotting_output_diagrams

The bar charts are under Step3_plotting_output_charts - Figure D3: emissions_base_q_bar and emissions_changes_base_q_bar

- Figure D4: emissions_base_p_bar and emissions_changes_base_p_bar

- Figure D5: transport_emi_base_p_bar and transport_emi_changes_base_p_bar