

Replication package for “The Brexit Vote, Productivity Growth and Macroeconomic Adjustments in the United Kingdom”

This README file explains the replication package for the paper “The Brexit Vote, Productivity Growth and Macroeconomic Adjustments in the United Kingdom” by Ben Broadbent, Federico Di Pace, Thomas Drechsel, Richard Harrison and Silvana Tenreyro, published in The Review of Economic Studies.

Overview

This README is organized into three parts. The document file first provides details about data sources and access descriptions for all data used across the paper (see Part A). It then provides detailed instructions to replicate the results (see Part B). Finally, it provides further details on data construction (see Part C).

A Data Availability and Provenance Statements

The following data used in the paper are publicly available:

- Eurostat National Accounts data [1], used in Section 2.2 and Appendix A. These data can be freely downloaded. At the time of creating our data set, they were directly accessible online at <https://ec.europa.eu/eurostat/web/national-accounts/database>. Accessing the data currently requires setting up a free “EU Login” account.
- OECD National Accounts data [2] (<https://stats.oecd.org/>), used in Section 2.2 and Appendix A. These data can be freely downloaded.
- Exchange rate data - used in Section 2.2 and Appendix A.
 - Euro-Dollar exchange rate: retrieved from FRED [3] (<https://fred.stlouisfed.org/>)
 - GDP deflators for US, Canada, Australia: retrieved from FRED [3] (<https://fred.stlouisfed.org/>)
 - OECD bilateral exchange rates: retrieved from the OECD [2] (<https://stats.oecd.org/index.aspx?queryid=169>)
- ONS National Accounts and Labor Market Statistics [4], used in Sections 2.1, 4 and 5.3 of the paper and Appendix D. These data can be freely downloaded from the ONS website <https://www.ons.gov.uk/>
- US CPI annual inflation and US 3-month Treasury Bill: retrieved from FRED [3] (<https://fred.stlouisfed.org/>), used in Section 4 of the paper. Data can be freely downloaded from the FRED website.

- US CPI inflation expectations - retrieved from SPF [5], used in Section 4 of the paper. Data can be freely downloaded from the Federal Reserve of Bank Philadelphia (<https://www.philadelphiafed.org/surveys-and-data/real-time-data-research/median-forecasts>).

Data source references

1. **Eurostat**. 1997:Q1-2016:Q2. “Basic breakdowns of main GDP aggregates and employment (by industry and asset)”. <https://ec.europa.eu/eurostat/web/national-accounts/data/database> (accessed 18 July 2021). The list of countries and sectors can be found in Tables A.1 and A.2 of Appendix A.
2. **OECD**.
 - 1997:Q1-2016:Q2. “Currency exchange rates, monthly average (aggregated to quarterly)”, <https://stats.oecd.org/index.aspx?queryid=169> (accessed 28 July 2021). The list of countries can be found in Tables A.1 and A.2 of Appendix A.
 - 1997:Q1-2016:Q2. “GVA (output approach) and employment”. <https://stats.oecd.org/Index.aspx?DataSetCode=QNA> (accessed 17 July 2021). The list of countries and sectors can be found in Tables A.1 and A.2 of Appendix A.
3. **FRED**.
 - 1997:Q1-2016:Q2. “Currency Conversions: US\$ Exchange Rate: Average of Daily Rates: National Currency: USD for the Euro Area (19 Countries) (aggregated to quarterly)”. Series code: CCUSMA02EZM618N. <https://fred.stlouisfed.org/> (accessed 3 August 2021).
 - 1997:Q1-2016:Q2. “GDP implicit price deflators (USA, Canada, Australia)”. Series codes: USAGDPDEFQISMEI, CANGDPDEFQISMEI, AUSGDPDEFQISMEI. <https://fred.stlouisfed.org/> (accessed 28 July 2021).
 - 1987Q1-2016Q2. “TB3MS - 3 Month Treasury Bill: Secondary Market, Percent, Quarterly, NSA”. <https://fred.stlouisfed.org/series/TB3MS> (accessed 31 September 2021).
 - 1987Q1-2016Q2. “CPIAUCSL_PC1 - Consumer Price Index for all urban consumers: All Items in U.S. City Average, Percentage Change from Year Ago, Quarterly, SA”. <https://fred.stlouisfed.org/series/CPIAUCSL> (accessed 31 September 2021).
4. **ONS**.
 - 1997-2018. “Supply and Use Tables, Annual”. <https://www.ons.gov.uk/economy/nationalaccounts/supplyandusetables/datasets/inputoutputsupplyandusetables/current> (accessed 17 October 2017 and 30 October 2020).

- 1990-2019. “GDP output approach – low-level aggregates, Quarterly and Annual, SA”. <https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/ukgdpolowlevelaggregates/current> (accessed 31 March 2021).
- 1994Q1-2019Q4. “Labour productivity by industry division, Average Total Hours, by Industry, Quarterly, SA”. <https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/datasets/labourproductivitybyindustrydivision> (accessed 18 January 2021).
- 1987Q1-2019Q4. “UK Economic Accounts time series, CP and CVM, £m, Annual and Quarterly, SA.” <https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/unitedkingdomeconomicaccounts/current> (accessed 30 June 2021 and 30 September 2021).
- 1987Q1-2019Q4. “Consumer trends: CVM, £m, Annual and Quarterly, SA.” <https://www.ons.gov.uk/economy/nationalaccounts/satelliteaccounts/datasets/consumertrendschainedvolumemeasureseasonallyadjusted/current> (accessed 30 June 2021).
- 1987Q1-2019Q4. “Consumer trends: CP, £m, Annual and Quarterly, SA.” <https://www.ons.gov.uk/economy/nationalaccounts/satelliteaccounts/datasets/consumertrendscurrentpricesseasonallyadjusted/current> (accessed 30 June 2021).
- 1997Q1-2019Q4. “Business investment by industry and asset: CP, £m, Quarterly, SA.” <https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/businessinvestmentbyindustryandasset/current> (accessed 26 April 2021).
- 1997-2014. “Breakdown of gross operating surplus/mixed income of the UK by industry section”. <https://www.ons.gov.uk/economy/grossdomesticproductgdp/adhocs/007583breakdownofgrossoperatingsurplusmixedincomeoftheukbyindustrysection2007to2014> (accessed 10 October 2017).
- 1987Q3-2019Q4. “LFS: Population Aged 16+: UK: All: 000s, Quarterly”. <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/timeseries/mgsl/lms/previous> (accessed 23 March 2021).
- 1987Q3-2019Q4. “LFS: Total actual weekly hours worked (millions): UK, All, Quarterly, SA”. <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/timeseries/ybus/lms/previous> (accessed 18 May 2021).
- 1987Q3-2019Q4. “Number of People in Employment (aged 16 and over), 000s, Quarterly, SA”. <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/timeseries/mgrz/lms/previous> (accessed 19 May 2021).
- 2000M1-2019M12. “AWE: Whole Economy Level: Total Pay Excluding Arrears, £, Monthly, SA”. <https://www.ons.gov.uk/employmentandlabourmarket/peopleinw>

[ork/earningsandworkinghours/timeseries/kab9/emp/previous](#) (accessed 18 May 2021).

- 1987M7-2000M9. “AWE Historical: Whole Economy Level: Total Pay Excluding Arrears, £, Monthly, SA”. Bank of England (accessed 18 May 2021).

5. **Survey of Professional Forecasters.** “CPI6 - Consumer Price Index (CPI), Median Level Forecast Data for Levels”. <https://www.philadelphiafed.org/surveys-and-data/real-time-data-research/median-forecasts> (accessed 31 September 2021).

B Replication Instructions

The folder where the README file is located contains the following subfolders:

- **Section2**
- **Section4**
- **Section5**

Following the folder structure, the instructions that follow are organized in three sub-parts (corresponding to the three sections in the paper - and associated Appendices - where results are reported), as the different sections of the paper use distinct methods and data.

B.1 Replication of results for Section 2

B.1.1 Computational Requirements

The hardware, OS and software used are listed below. With this configuration, any codes for Section 2 run in less than one minute.

- CPU: 12th Gen Intel Core i5-12500, 3 GHz
- RAM: 16GB
- OS: Windows 10 Enterprise
- Software: Stata version 16. Extra Stata packages required: winsor, sum2docx, ftools, reghdfe, outreg2 (use “ssc install” command to install these).

In all Stata do files, the current directory at the top needs to be adjusted. The code has not been tested on other hardware, operating systems or software versions.

B.1.2 Replication of results in Section 2 (and related appendices)

Note that the instructions here are for the results in Section 2.2. The code to produce Figure 1 in Section 2.1 is contained in the **Section5** folder: see the instructions [B.3.3](#) of this document below.

The folder **Section2/Figures_Tables_Section2** contains the data underlying

- Table 1, Figure 2
- Appendix Tables A1, A2, A3, A4

It also contains a MATLAB function to create Figure 2 from its underlying data.

The subfolder **Section2/Replication_Section2.2** contains the raw data and Stata do files for Section 2.2 and Appendix A. The subfolders beginning with **Data** contain the underlying raw data.

Further explanations on how this data was retrieved are contained in Section C of the readme file. The subfolder “Do files” contains the Stata do files.

- 05_regressions.do runs the regressions, i.e. creates Tables 1, A3, A4.
- 04_summary_stats.do creates the data for Figure 2, and Tables A1, A2.
- The do files beginning with 00_ to 03_ create the data set for the regressions from scratch.

B.2 Replication of results for Section 4

B.2.1 Computational Requirements

The hardware, OS and software used is listed below (and the timings detailed in Section B.2.3 refer to this configuration):

- CPU: Intel Core i5-6300U
- RAM: 16GB
- OS: Windows 10 Enterprise
- Software: MATLAB 2016b (64bit), Dynare version 4.5.7, Excel 2016.

The code has not been tested on other hardware, operating systems or software versions.

B.2.2 Replication package structure

The folder **Section4** contains the following subfolders:

- **Data** Contains Excel spreadsheets with data (and data transformations) to plot Figure 1, compute Tables 6 and E.1 and plot Figures D.1 to D.4. The folder has two spreadsheets: one with all final data and one with only the transformed data (to estimate the model). The folder also contains a subfolder where data and data transformations are stored.
- **Figures** Contains Figures D.1-D.4 of the Appendix (in .eps format). The figures are stored after running the Matlab script as explained below.
- **Estimation** Contains dynare code to run the estimation of the model using data from 1987Q3 until 2016Q2.
- **Results** Contains estimation results files generated from estimation (in .mat format) and also Tables 2-5 corresponding to Section 4 of the paper (in .xlsx format).

B.2.3 Replication of results in Section 4 (and related appendices)

Data

There are three files and one subfolder in this folder:

1. The spreadsheet **BrexitPaperData.xlsx** contains all the transformed data used in Sections 2.1, 4, 5 and Appendices D and E. The script to plot the figures in Appendix D reads from this spreadsheet.
2. **Estimation.xlsx** spreadsheet contains data to run the estimation of the model. The dynare script (**.mod**) reads data from this file.
3. **data_plots.m** script produces Figures D.1-D.4, reading from **BrexitPaperData.xlsx**, and saves the figures in **.eps** format into the **Figures** folder.
4. The subfolder **Transformations** contains 8 spreadsheets with data and data transformations. Additional information about data transformations can be found in [C](#).

Model Estimation

The main script **run_estimation.m** clears the workspace, runs the estimation and stores results. Paths are expressed relative to the working directory containing the scripts. **Note that line 4 of this script also specifies the dynare path, which should be modified to match the user's configuration.** To run the script, ensure that the dynare path is correctly set. The results in the paper were produced using **Dynare v4.5.7** and the codes have not been tested on other versions. Version 4.5.7 can be downloaded from the 'release archive' section of the Dynare website: <https://www.dynare.org/release/>. Computation times reported are based on the configuration described in Section [B.3.1](#).

The script **run_estimation.m** in the **Estimation** folder saves the estimation results in worksheet **Table5** of **TablesPaper.xlsx**. The worksheet **Table5** in the spreadsheet has been saved under the same format as it appears in Section 4.3. In order to execute the file, the **Estimation** folder needs to be specified as the current directory in MATLAB. There are two options within the script: **load_results=1** loads only selected stored results from **Results/soetnt_res.mat** and **load_results=0** runs the full Bayesian estimation of the model. Prior and posterior estimates have also been stored separately in **soetnt_res.mat**. Whilst the option that reads results takes less than one minute to execute, the estimation of the model takes approximately 6 hours to execute.

Under option **load_results=0**, the script executes the dynare file **soetnt.mod**. Upon file execution, dynare reads the observables from the **Estimation.xlsx** spreadsheet. After completion, Matlab/Dynare generates a file with results (**soetnt_results.mat**) in the same folder. The estimation results can be retrieved from the **oo_** structure. Prior and posterior distributions have been stored in worksheet **Table5** of the spreadsheet **TablesPaper.xlsx**.

B.2.4 Production of Figures D.1-D.4 (Appendix)

The script `data_plots.m` in the **Data** folder produces Figures D.1 and D.4 in the Appendix. **Note that line 6 of this script also specifies the dynare path, which should be modified to match the user's configuration.** The script takes less than 1 minute to execute. The script reads from the spreadsheet `BrexitPaperData.xlsx`. The script produces 4 figures that are saved in the **Figures** folder in `.eps` format.

B.3 Replication of results for Section 5

B.3.1 Computational Requirements

The hardware, OS and software used is listed below (and the timings detailed in Part [B.3.3](#) refer to this configuration):

- CPU: Intel Core i5-6300U
- RAM: 16GB
- OS: Windows 10 Enterprise
- Software: MATLAB 2020b (64bit), Dynare version 4.5.7.

The code has not been tested on other hardware, operating systems or software versions.

B.3.2 Replication package structure

The folder **Section5** contains the following subfolders:

- **Data** Contains Excel spreadsheet with the data used to plot Figure 1 and Tables 6 and E.1. This data is a subset of the dataset detailed in Section [B.2](#) of this README file. The spreadsheet `selectedDataSeries.xlsx` contains a subset of worksheets in `Section4/Data/Transformations/DataSOETNT_Dec2020.xlsx`. The spreadsheet contains an additional transformation to compute the model consistent trade balance.
- **Figures** Contains figure outputs (in `pdf` format) from the plotting codes.
- **Functions** Contains functions used to generate and plot the results.
- **Results** Contains results files (in `mat` format) generated from the Brexit simulations.

B.3.3 Replication of results in Section 5 (and related appendices)

The main scripts call the script `tidyUpAndSetPath.m`, which clears the workspace and adds the relevant paths for the data files, functions, figures and results. These are expressed relative to the working directory containing the scripts. **Note that line 12 of this script also specifies the dynare path, which should be modified to match the user's configuration.** The results

in the paper were produced using **Dynare v4.5.7** and the codes have not been tested on other versions. Version 4.5.7 can be downloaded from the ‘release archive’ section of the Dynare website: <https://www.dynare.org/release/>.

Some of the scripts described below require pre-computation of results by other scripts. It is therefore recommended that they are executed in the order listed below. Computation times reported are based on the configuration described in Part B.3.1.

Brexit simulations Two scripts produce the relevant results:

1. `runBrexitSimVariants.m` produces the baseline Brexit simulation reported in Section 5 of the paper, together with the variants reported in Appendices E and F. The script takes approximately 3 minutes to execute. Results are saved as `.mat` files in the **Results** folder.
2. `plotBrexitSimFigures` plots Figures 3–4 in the main text and Figures E.1–E.6 and F.1–F.4 in Appendices E and F. The script takes less than 1 minute to execute. Results are saved (in pdf format) in the **Figures** folder. Note that the results files generated by `runBrexitSimVariants.m` must exist before this script is executed.

Comparison of simulations with data Two scripts produce the relevant results:

1. `compareSimAndData.m` produces Table 6 in the paper. The script takes less than 1 minute to execute. The result is saved as `simVsDataTable.tex` in the **Figures** folder.
2. `compareSimAndDataRobustness.m` produces Table E.1 in Appendix E. The script takes less than 1 minute to execute. Results are saved as `simVsDataTableRobustness.tex` in the **Figures** folder.

Note that the results files generated by `runBrexitSimVariants.m` must exist before these scripts are executed.

B.3.4 Production of Figure 1

The script `plotFigure1.m` produces Figure 1 in the paper. The script takes less than 1 minute to execute. The results is saved as `Figure1.pdf` in the **Figures** folder.

C Additional Details on Data Construction

C.1 Data Construction for Section 2.2 and Appendix D

How the Eurostat data was retrieved (July 2021):

- Go to <https://ec.europa.eu/eurostat/web/national-accounts/data/database>
- Select “Quarterly national accounts” then “Basic breakdowns of main GDP aggregates and employment (by industry and asset) (namq_10_bbr)”.

- Click on the “Data explorer” icon
- Make appropriate selections, by clicking on the “+” Icon next to the 6 dropdown menus
 - TIME: start in 1995Q1
 - Seasonal adjustment: Seasonally and calendar adjusted data
 - GEO: Bulgaria, Romania, Cyprus, Malta, Croatia
 - Unit of measure: Chain linked volumes (2015), million euro
 - National Accounts Indicator: Value added, gross
- Download as csv files; gives the files starting with “00_”
- Then manually add the “Quartnum” variable and save as xls; gives the files starting with “01_”
 - The Quartnum variable will be used in Stata to properly define the data as quarterly
 - Also manually add a SUBJECT variable that consists of the first letters of sector name
 - Also manually erase “:” entries in the value column
- Then continue with Stata do files

How the OECD data was retrieved (July 2021):

- Go to <https://stats.oecd.org/Index.aspx?DataSetCode=QNA>
- Customize table
- Select all OECD countries (38)
- Go subject by subject: GVA (GDP output approach) / employment
- In each case; select the total as well as all ISIC Rev.4 sectors and subsectors (Careful: for employment/hours there is no total service sector, only the subcategories. Therefore these data have 12 options for the field 'Subject', whereas the GVA data has 13 options.)
- Measure:
 - For GVA, choose National currency, chained volumes, national reference year, quarterly levels, seasonally adjusted
 - For employment, choose: Persons SA/Persons nonSA/Hours SA/Hours Non SA
 - For compensation, choose: National currency, current prices, quarterly levels, seasonally adjusted
- Frequency: start in 1990Q1

- Download as csv files; gives the files starting with “00_”
- Then manually add the “Quartnum” variable and save as xls; gives the files starting with “01_” (the Quartnum variable will be used in Stata to properly define the data as quarterly)
- Then continue with Stata do files

How the exchange rate data was retrieved (July 2021):

- OECD nominal exchange rates vis a vis USD was retrieved from <https://stats.oecd.org/index.aspx?queryid=169#>. Select all non-Euro OECD countries and Euro Area (21); Subject: Currency exchange rates, monthly average; Time and frequency: start in 1990Q1
- USD EURO nominal exchange rate: Retrieved from FRED, series code CCUSMA02EZM618N
- GDP deflators for US, CAN, AUS: Retrieved from FRED, series codes USAGDPDEFQISMEI, CANGDPDEFQISMEI, AUSGDPDEFQISMEI

C.2 Data Construction for Section 4 and Appendix E

The subfolder **Section4/Data/Transformations/** contains 8 spreadsheets.

The spreadsheet **Tradability&Shares_9718.xlsx** uses as input data from the “Supply and Use Tables” (accessed 30 October 2020) to compute the tradability index, which is used to classify SIC2 sectors into tradable and nontradable sectors. The spreadsheet also computes tradable consumption shares. This spreadsheet also contains input for Table 2 and for Figure D.1 in the Appendix. This output has been hardpasted in **Section4/Data/BrexitDataPaper.xlsx**.

The spreadsheet **Hours_LR_Sep2020.xlsx** uses data from “Labour productivity by industry division, Average Total Hours, by Industry” (accessed 18 January 2021) and the sectoral classification obtained in **Tradability&Shares_9718.xlsx** spreadsheet to construct tradable and nontradable time series for hours worked. This is done by adding up the tradable and nontradable sectors. Transformations of these data are used to produce Tables 6 and E.1 and to estimate the model. Green cells sheets have been hardpasted in sheet **sectoral_raw_data** of **DataSOETNT_Dec2020.xlsx**. Note that order may not be necessary the same. This output has been hardpasted in **Section4/Data/BrexitDataPaper.xlsx**.

The spreadsheet **T_NT_output_sa_LR_Dec2020.xlsx** combines data taken from “GDP output approach – low-level aggregates” (accessed 31 March 2021) with the sectoral classification in **Tradability&Shares_9718.xlsx** spreadsheet to construct tradable and nontradable GVA time series and the relative price of nontradable goods (P). This is done by chain-linking the tradable and nontradable sectors. Transformations of these data are used to produce Figure 1, Tables 6 and E.1 and to estimate the model. Green cells in green sheets have been hardpasted in sheet **sectoral_raw_data** of **DataSOETNT_Dec2020.xlsx**. Order may not be necessary the same. This output has been hardpasted in **Section4/Data/BrexitDataPaper.xlsx**.

The spreadsheet `TNT_consumption_LR_sa_Dec2020.xlsx` combines data taken from “Consumer Trends: CVM and CP” (30 June 2021) with the sectoral classification in `Tradability&Shares_9718.xlsx` to construct time series for tradable and nontradable consumption (CVM and CP) and the consumption price deflators. The transformation of this data is used to produce Tables 6 and E.1. This is done by chain-linking the tradable and nontradable products. The spreadsheet also contains the mapping between SIC2 industries and COICOP categories. Green cells in the `AggregationQly` sheet have been hardpasted in sheet `sectoral_raw_data` of `DataSOETNT_Dec2020.xlsx`. Order may not be necessary the same. This output has been hardpasted in **Section4/Data/BrexitDataPaper.xlsx**.

The spreadsheet `TNT_investment_Feb2022.xlsx` uses data in “Business investment by industry and asset” (26 April 2021) and “UK Economic Accounts time series” (accessed 30 June 2021) to compute the time series for nominal tradable investment and nontradable investment used for the computation of the trade balance in Section 5.3 of the paper. The calculations can be found in **Section5/Data/selectedDataSeries.xlsx**. Since not all data at SIC2 digit available, the sector classification in `Tradability&Shares_9718.xlsx` is used at a slightly higher level of disaggregation. The quarterly data is in current prices and it is non-seasonally adjusted. The spreadsheet is simply added up across tradable and nontradable sectors. Green cells in `TNT_investment.xlsx` sheet have been hardpasted in sheet `sectoral_raw_data` of `DataSOETNT_Dec2020.xlsx`. Note that the order may not be necessary the same. The output has been hardpasted in **Section4/Data/BrexitDataPaper.xlsx**.

The spreadsheet `DataSOETNT_Dec2020.xlsx` uses raw data from “LFS: Total actual weekly hours worked”, “Number of People in Employment”, “AWE: Whole Economy Level: Seasonally Adjusted Total Pay Excluding Arrears” and “LFS: Population Aged 16+: UK: All: 000s, Quarterly” and “UK Economic Accounts time series” (accessed 30 June 2021) contains all transformations to estimate the model, generate Figure 1, compute Table 6 and produce Figures D.1-D.4. The orange cells in the sheet `DataQ_estimation87` have been hardpasted in **Section4/Data/Estimation.xlsx**. Note that order may not be necessary the same.

The spreadsheet `RealRates.xlsx` uses data from FRED (series codes `TB3MS` and `CPIAUCSL_PC1` - accessed 31 September 2021) and SPF (`CPI6`, Median Level Forecast Data for Levels - accessed 31 September 2021) to calculate real rates used as observables in the estimation of the model (data is hardpasted in **Section4/Data/DataSOETNT_Dec2020.xlsx**).

The spreadsheet `LabourShares.xlsx` uses input data from the “Supply and Use Tables” (accessed 17 October 2017) and in “Breakdown of gross operating surplus/mixed income of the UK by industry section” (accessed 10 October 2017) to compute labour shares in the tradable and nontradable sectors. This spreadsheet also contains input for Figure D.1 in the Appendix. The cells in the green sheet has been hardpasted in **Section4/Data/BrexitDataPaper.xlsx**.