

Restarting the economy while saving lives under Covid-19 Replication Documentation R

November 8, 2020

1 Introduction

In this documentation we provide the necessary instructions to replicate all the results and figures reported in the paper using R. The default calibrated parameters are the ones on which our simulations are based. The ZIP file should be unzipped by keeping the saved structure of folders. The empirical work in the paper is based on the timing reported in the following table:

Table 1: Relevant dates for the simulation

| | Observed Past | | | | Simulated Future | | |
|------|-------------------------------|----------------------------------|----------------------------------|------------------------|--------------------------------|---------------------------------|-------------------------------------|
| | Appearance of the virus | Beginning of observed data | Beginning of the lock down | Start of Phase 2 | Start of new school year | Start of Simulation t^* | End of simulation $t^* + 364$ |
| Date | January 1 2020 | February 24 2020 | March 8 2020 | May 4 2020 | September 14 2020 | November 1 2020 | October 31 2021 |

The relevant parameters determining the Basic Reproduction Matrix at time zero are calibrated using the for the pre-lockdown period and the post-lockdown period by comparing the model simulated series with the actual ones (in particular with observed mortality). After calibration we proceed to simulation both by simulating specific policies and by constructing the Efficient Pareto Frontier.

2 Files

The Replication documentation contains 2 folders, **With Behavioural Response** and **Without Behavioural Response**. The former contains the following folders and files,

while the latter has a similar structure but only contains the files to produce the Pareto frontier in the case of absence of behavioural response.

- **PlotFiguresA.R**: to plot figures for the calibration.
- **PlotFiguresB.R**: to plot figures for the simulation of the 5 policies.
- **PlotFiguresC.R**: to plot figures for the Pareto frontier.
- **PlotFiguresD.R**: to plot figures for the initial comparison between Lombardia and Veneto.
- **PlotMatrices.R**: to plot the R_0 equivalent matrices. It used as input csv files obtained by running **PlotFiguresB.R**.
- **Mobility_analysis.R**: to replicate the mobility analysis.

FOLDER Code:

- **readCOVID.R**: download data form Protezione Civile and the Global Mobility Report by Google.
- **SETUP.R**: to set the calibrated values using *Ferguson et. al.* parameters.
- **SETUP_CDC.R**: to set the calibrated values using *Garg et. al.* parameters.
- **SEIR_HC_SEC_AGE.R**: to define the workers activation policy vector.
- **Model.R**: to solve the differential equation system.
- **Pareto.R**: to simulate the model and to find the efficient policies.
- **AssignNames.R**: to assign the same id number to all efficient policies in both regions.
- **mobility dataset.R**: to generate the dataset for the mobility analysis.

FOLDER Data:

- **Global_Mobility_Report.csv**: mobility data from Google.
- **MOBILITY_ANALYSIS.csv**: data generated by running **mobility dataset.R**.
- **LOMBARDIA.csv** and **VENETO.csv**: data from Protezione Civile.
- **ICU_Lomb_Ven.xlsx**: Intensive care units available in Lombardia and Veneto.

- a list of other files which are the output of *Pareto.R* or *AssignNames.R* for different values of the parameters. They are used to plot the Pareto frontier. There are three different types of files with a different prefix: **EFF_LOM**, **DATI_LOM** and **DATI_LOM_N**.¹ The suffix instead is given according to the specified parameters of interest. For example, in **DATI_LOM_bm_XX_Tinf1_X_XXX_XXXX.xlsx**, XX represents the value of $\beta(m)$, X the value of *TINF1*, XXX the name of the region and XXXX is "_CDC" if parameters from *Garg(2020)* are selected otherwise it is empty.
- **MOBILITY_ANALYSIS.csv**: mobility analysis dataset.

FOLDER graphs:

- A list of folders where graphs are properly saved.

3 Mobility analysis

The behavioural response regressions, Figure (2) and Figure (3) can be replicated by running **Mobility_analysis.R**. Note it takes as input **MOBILITY_ANALYSIS.csv** that can be replicated by running **readCOVID.R** and **mobility dataset.R**.

4 Calibration

The first step for the replication of our calibration exercise is the creation of an updated database by running **readCOVID.R**. It downloads data for Lombardia and Veneto from the website of Protezione Civile and constructs two CSV files with the names of the regions.²

The calibration of the model is implemented by running **PlotFiguresA.R**. The programme allows the user to select *Region* (1 for Lombardia and 2 for Veneto), *Bio_Parm* ("Ferguson" or "CDC_mean"), *bm_Sim* (the $\beta(m)$ parameter for the simulation period), *TINF1* (to allow for the early detection) and *TimeHoriz* (the end of the simulation period). It calls **SEIR_HC_AGE.R** that runs the appropriate setup file according to *Bio_Parm* and allows to define the workers activation policy vector for the simulation. Then, it runs **MODEL.R**, that solves the differential equation system. From the Final output a number of graphs are produced to evaluate the fit of the model against observed data. Note that you need *ICU_Lom_Ven.xlsx*, *LOMBARDIA.csv* and *VENETO.csv* as input to be able to plot the graphs.

¹Similarly for Veneto we have **EFF_VEN**, **DATI_VEN** and **DATI_VEN_N**.

²Notice that Protezione Civile may add other columns to the dataset. This may require you to properly select the required variables.

5 Simulation of Specific Policies

After Calibration, **PlotFiguresB.R** runs **SEIR_HC_AGE.R** for the five specific policies considered in the paper to produce the figures of the simulation.

6 Constructing the Efficient Frontier

PlotFiguresC.R constructs the Efficient Frontier and produce related figures. Note that you need two excel files (with the desired parameter specification) as input to be able to plot the graphs. In the folder *Data* we provide the excel files for replicating the figures in the paper, however for alternative specification we recommend to follow this procedure. (1) Run twice **Pareto.R** (one for Lombardia and one Veneto) after selecting the desired parameters for both regions.³ The code gives as output two files named **DATI_LOM** and **DATI_VEN** plus the value of the selected parameters. (2) Run **AssignNames.R** that assigns the same ID number to the same efficient policies in both regions. It returns two files named **DATI_LOM_N** and **DATI_VEN_N**. (3) Run **PlotFiguresC.R** specifying the same parameters chosen before.

Besides, the file **Pareto.R** produces also an excel file named **EFF_XXX** that contains a 3x1 vector whose entries tells if policies *SEC*, *AGE* and *AGE_SEC* respectively are efficient.

Finally, the same procedure can be applied to replicate the efficient frontier without behavioural response using the files in the folder named **Without Behavioural Response**.

³It may takes more than one hour to run.