Submitted material

The zipped folder "SUBMITTED DATA & PROGRAMS" contains the data to construct the empirical figures and the programs to solve and simulate the model presented in the article "International Spillovers and Bailouts". It also contains the programs to replicate the graphs constructed with model generated data.

Software and hardware

Software: The empirical graphs are constructed with Microsoft Excel, version 2210. The program that solves the one-period model is written in Matlab, version R2021b. The programs that solve and simulate the infinite horizon model are written in Fortran 90 and compiled with Visual Fortran Intel(R) 64, Version 11.0.061. The programs that replicate the graphs using model generated data with the infinite horizon model are written in Gauss 64, Version 22.

Hardware: All programs were run on a personal computer: Intel(R) Xeon(R) Silver 4215R CPU 3.20GHz 3.19 GHz, with 32.0 GB of RAM. Runtime for the execution of each program is indicated below.

Data Availability Statement

- Data used to construct the first graph in Figure 1 is from Bruegel database of sovereign bond holdings developed in Merler and Pisani-Ferry (2012). Data is in the public domain and freely accessible (https://www.bruegel.org/dataset/sovereign-bond-holdings).
- Data used to construct the second graph of Figure 1 is from European Central Bank, Statistical Data Warehouse, Balance Sheet Items. Data is in the public domain and freely accessible (https://sdw.ecb.europa.eu/browseExplanation.do?node=1491)
- Data used to construct Figure 2 is from Mitchener and Trebesch (2021). Data is in the public domain and freely accessible.
- Data used to construct the first graph in Figure 9 and Figure 15 is from Bruegel database of sovereign bond holdings developed in Merler and Pisani-Ferry (2012). Data is in the public domain and freely accessible (https://www.bruegel.org/dataset/sovereign-bond-holdings). The GDP data is from Federal Reserve Economic Data (FRED). Data is in the public domain and freely accessible (https://fred.stlouisfed.org).
- Data used to construct the second graph in Figure 9 is from Global Financial Data. Data is proprietary but publicly accessible for a fee (https://globalfinancialdata.com).

Description of zipped folder and subfolders

The zipped folder "SUBMITTED DATA & PROGRAMS" contains four subfolders:

"1. DATA FOR FIGURES 1,2,9,15"

It contains the excel files with the data to construct the empirical figures.

"2. ONE PERIOD MODEL"

It contains the program that solves the one-period model and generates the graphs for this version of the model.

"3. BASELINE MODEL & SENSITIVITY"

It contains all programs for the baseline model necessary to replicate the tables and graphs generated from the infinite horizon model.

"4. EXTENDED MODEL WITH RANDOM PARTICIPATION - Online Appendix"

It contains all programs to solve the extended model with random participation to foreign financial markets. These programs are used to replicate the graphs generated with the extended model and presented in the online appendix.

We now describe the structure of each subfolder.

"1. DATA FOR FIGURES 1,2,9,15"

This folder contains three excel files.

1. "Data for Figure 1.xlsx".

    - This excel file contains data to construct Figure 1 in the paper. The first spreadsheet has the data for the first graph. The second spreadsheet has the first graph of Figure 1. The third spreadsheet has the data for the second graph of Figure 1. The fourth spreadsheet has the second graph of Figure 1. All other spreadsheets contain the raw data downloaded from the original sources.

      Data used to construct the first graph of Figure 1 is from Bruegel database of sovereign bond holdings. Data used to construct the second graph of Figure 1 is from the European Central Bank, Statistical Data Warehouse, Balance Sheet Items.

2. "Data for Figure 2.xlsx".

    - This excel file contains data to construct Figure 2 in the paper. The first spreadsheet contains the data and the second spreadsheet has the graph.

      The data is from Mitchener and Trebesch (2021).

3. "Data for Figure 9 & 15.xlsx".

    - This excel file contains data to construct Figures 9 and 15 in the paper. The first spreadsheet has the data to construct the first graph of Figure 9. It also contains the data for Figure 15. The second spreadsheet contains the first graph of Figure 9. The third spreadsheet contains the data to construct the second graph of Figure 9. The fourth spreadsheet contains the second graph of Figure 9. The fifth spreadsheet contains Figure 15.

      Debt data used to construct the first graph of Figure 9 and Figure 15 is from Bruegel database of sovereign bond holdings. The GDP data is from Federal Reserve Economic Data (FRED). Data used to construct the second graph of Figure 9 is from Global Financial Data.

“2. ONE PERIOD MODEL”

This folder contains the Matlab program “OwnBailout_Nov_2022.m” that solves the one-period version of the model and generates Figures 6, 7 and 8 in the paper.

`Runtime` “OwnBailout_Nov_2022.m”: `7 seconds`

“3. BASELINE MODEL & SENSITIVITY”

This folder contains seven subfolders. The first contains the programs to replicate the results from the simulation of the infinite horizon model presented in the main body of the paper. The next subfolders contain the programs that generate simulated data to construct the sensitivity Table 4 presented in the appendix of the paper. The description of the numerical procedure used to solve the model is provided in the online appendix. The printout of the output is in the log file called “Output_Log.TXT”. Following is the description of each subfolder.

- “1. Baseline model”

  This folder contains the Fortran program to solve the version of the model **without** debt renegotiation and the model **with** debt renegotiation. The folder also contains the Fortran programs that simulate the model and construct tables and graphs.

  To run all the programs, we follow these steps:

  (a) Compile and run the Fortran program “MainProg_NoReneg.f90”. Then compile and run the Fortran program “MainProg_Reneg.f90”. The two programs can be compiled and run by executing the batch file “run.bat”. Running the program will generate and save data in subfolder “SimData”.

  `Runtime` “MainProg_NoReneg.f90”: `16 minutes \& 9 seconds`

  `Runtime` “MainProg_Reneg.f90”: `16 minutes \& 54 seconds`

`Screen output:`

```
========================================================================
                               TABLE 1
========================================================================
 beta       Entrepreneur's discount factor        0.930
 nu         Elasticity of labor supply            1.000
 alpha      Capital income share in production    0.333
 phi        Production cost (depreciation)        0.390
 ro^S       Probability bailout in crisis         0.750
 ro^R       Probability commitment to repay       0.903
 eta        Bargaining power share                0.500
 Psi        Government weight on entrepreneurs    0.111
 lambda     Government dis-utility from debt      0.141
 mu^R       Relative size country R (mu^S=1)      1.255
 z distr    Distribution productivity             1.000    0.975    1.025
  0.900
 B1 distr   Distribution debt country S           0.332    0.295    0.369
  0.900
========================================================================
```

(b) Compile and run the Fortran program "Simulation.f90". The program can be compiled and run by executing the batch file "runsim.bat". Running the program will generate and save data in subfolder "PlotData". It also prints on the screen the data used to construct Table 2 and Table 3.

`Runtime` "Simulation.f90": `5 seconds`

`Screen output:`

```
AVEARGE STATISTICS WITH BAILOUT
Debt-to-outout ratio country S  (in %)                          67.13
Debt-to-output ratio country R  (in %)                          79.81
Interest rate country S  (in %)                                  1.32
Interest rate country R  (in %)                                  1.62
Unconditional repayment ratio  (in %)                           99.74
External transfers tau^e (% of Y^S conditional on bailout)       5.32
Domestic transfers tau^d (% of Y^S conditional on default)       9.44
Probability debt crisis                                          5.00
Spread conditional on debt crisis (in %)                         5.46
Spread conditional on default (no bailout) (in %)               26.72
Output country S                                                0.495
Output country R                                                0.493

Share of country R's debt held by Country S                     44.52
Public debt-to-output ratio Country R                           79.81

AVEARGE STATISTICS WITHOUT BAILOUT
Debt-to-outout ratio country S  (in %)                          68.96
Debt-to-output ratio country R  (in %)                          74.89
Interest rate country S  (in %)                                 -0.05
Interest rate country R  (in %)                                  0.87
Unconditional repayment ratio  (in %)                           99.20
External transfers tau^e (% of Y^S conditional on bailout)        NaN
Domestic transfers tau^d (% of Y^S conditional on default)       6.72
Probability debt crisis                                          4.98
Spread conditional on debt crisis (in %)                        19.67
Spread conditional on default (no bailout) (in %)               19.67
Output country S                                                0.483
Output country R                                                0.478

Share of country R's debt held by Country S                     44.76
Public debt-to-output ratio Country R                           74.89
```

(c) Compile and run the Fortran program "Simulation_EURO_CRISIS.f90". The program can be compiled and run by executing the batch file "runsim_EURO_CRISIS.bat". Running the program will generate additional data that will also be saved in subfolder "PlotData".

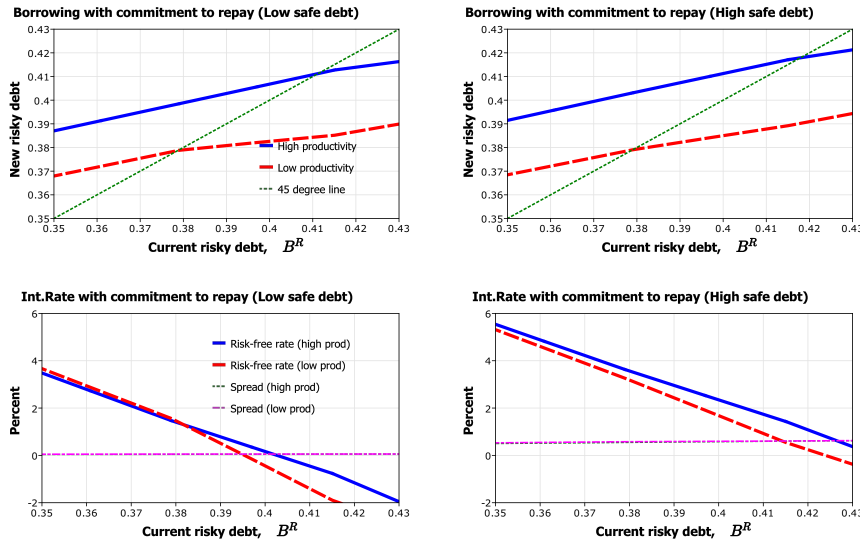
`Runtime` "Simulation_EURO_CRISIS.f90": `10 seconds`

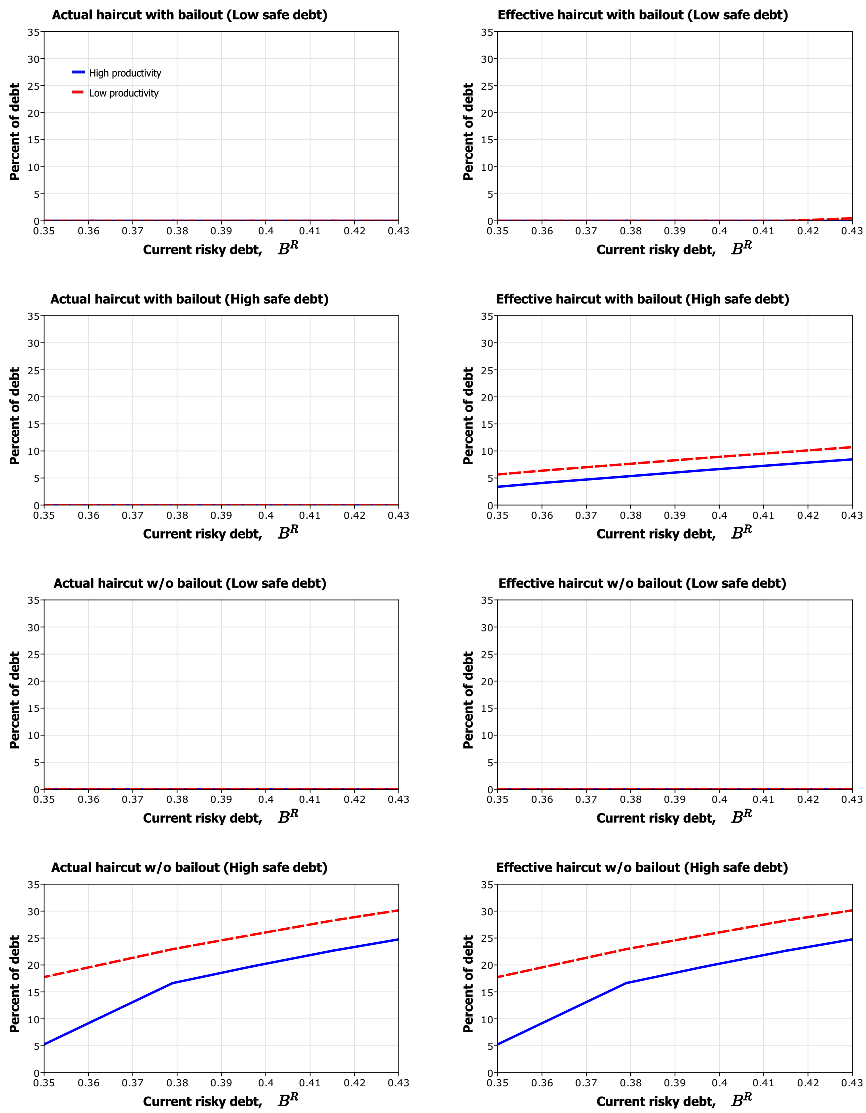
(d) We now open subfolder "PlotData" and run the GAUSS programs to construct the graphs.

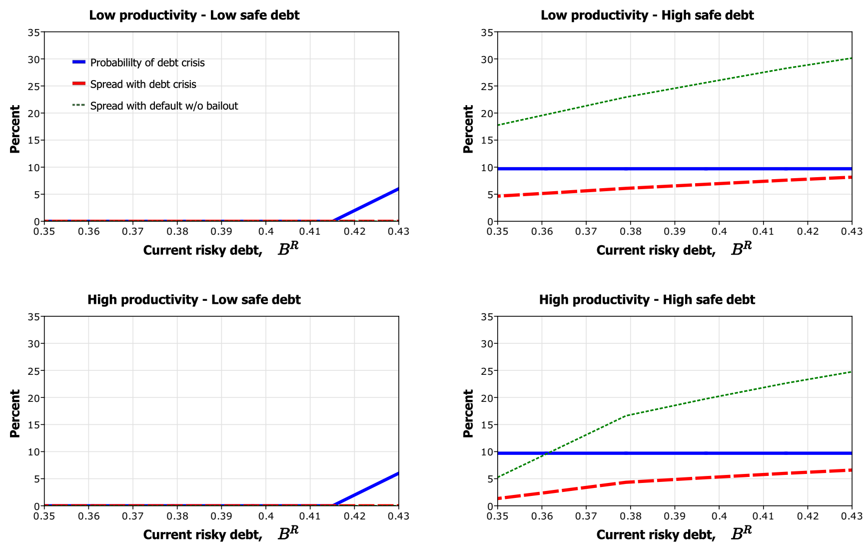
∗ Gauss program "MakePlot_Policies.gau" replicates Figures 10, 11, 12, 13, 14 presented in the paper.

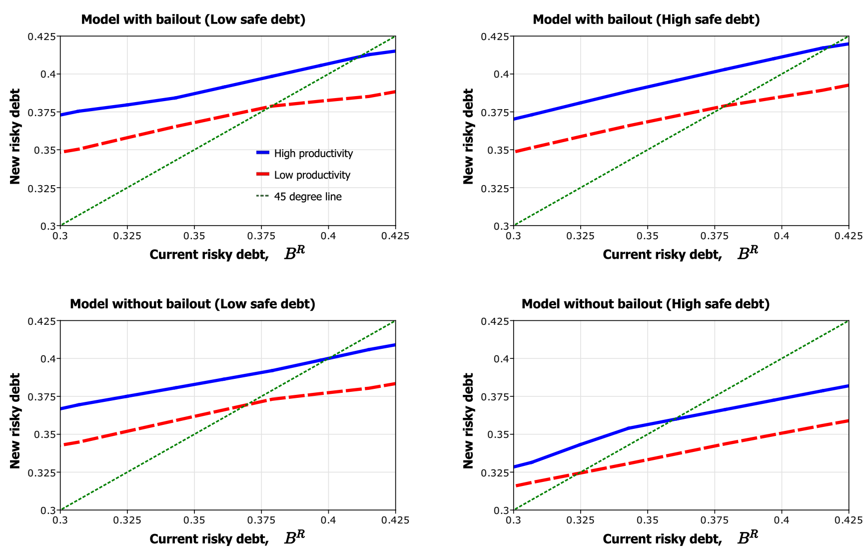
`Runtime` "MakePlot_Policies.gau": `10 seconds`

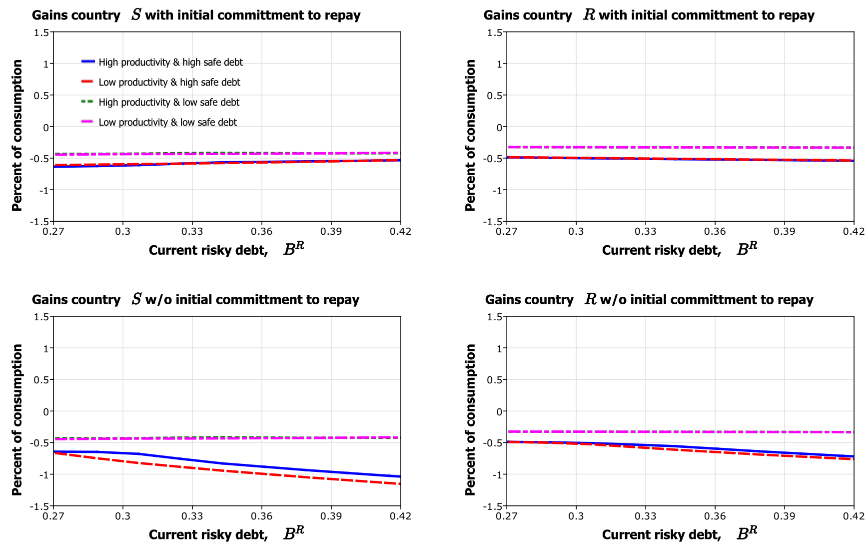
Screen output:




Actual haircut with bailout (Low safe debt)
Effective haircut with bailout (Low safe debt)
Actual haircut with bailout (High safe debt)
Effective haircut with bailout (High safe debt)
Actual haircut w/o bailout (Low safe debt)
Effective haircut w/o bailout (Low safe debt)
Actual haircut w/o bailout (High safe debt)
Effective haircut w/o bailout (High safe debt)
High productivity
Low productivity
Percent of debt
Current risky debt, B^R
0
5
10
15
20
25
30
35
0.35
0.36
0.37
0.38
0.39
0.4
0.41
0.42
0.43


Low productivity - Low safe debt
Low productivity - High safe debt
High productivity - Low safe debt
High productivity - High safe debt
Probability of debt crisis
Spread with debt crisis
Spread with default w/o bailout
Percent
Current risky debt, B^R

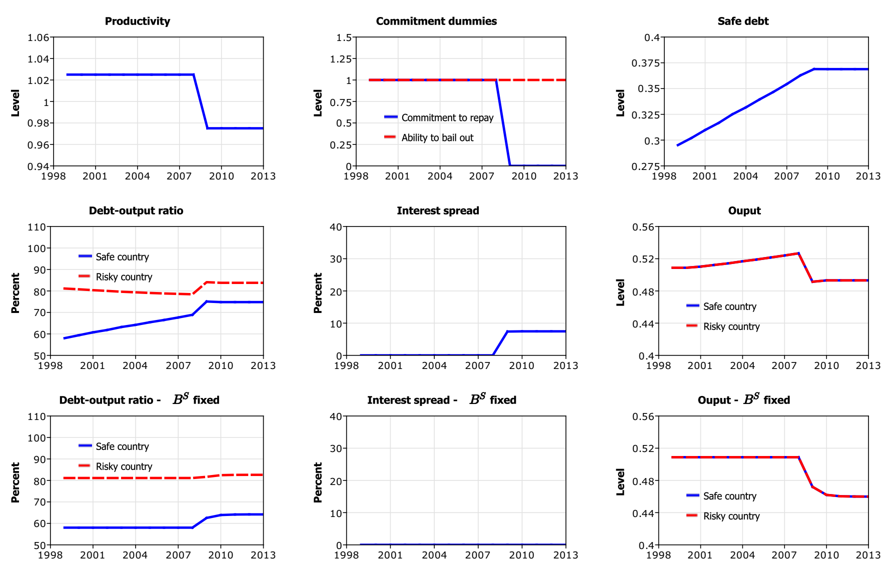

Model with bailout (Low safe debt)
Model with bailout (High safe debt)
Model without bailout (Low safe debt)
Model without bailout (High safe debt)
High productivity
Low productivity
45 degree line
New risky debt
Current risky debt, B^R

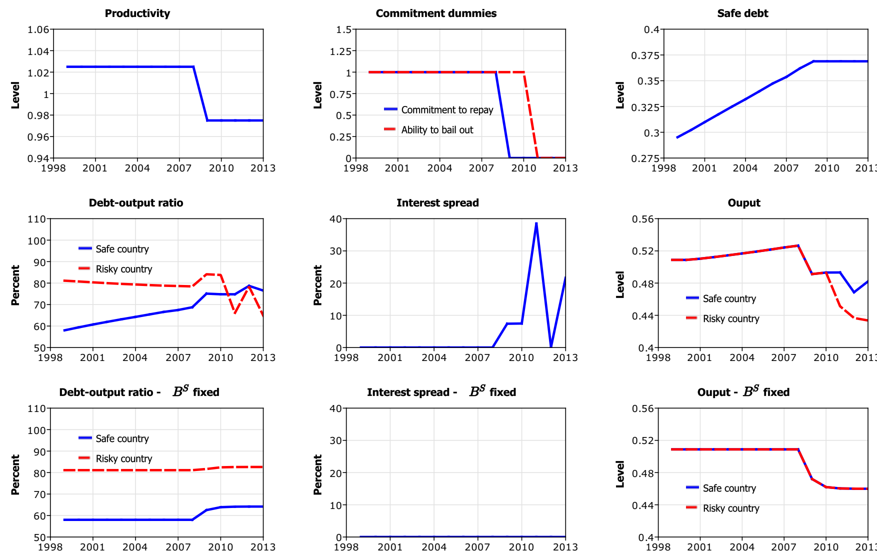


* GAUSS program "MakePlot_EURO_Simula.gau" replicates Figures 16, 17 presented in the paper.

  `Runtime` "MakePlot_EURO_Simula.gau": 7 seconds

`Screen output:`





- "11. Sensitivity_for_B^S"

  This contains two subfolders:

  1. Programs to solve and simulate the model after reducing B^S by 10 percent.
  2. Programs to solve and simulate the model after increasing B^S by 10 percent.

  To run these programs we follow these steps:

  (a) Compile and run the Fortran program "MainProg_NoReneg.f90". Then compile and run the Fortran program "MainProg_Reneg.f90". The two programs can be compiled and run by executing the batch file "run.bat". Running the program will generate and save data in subfolder "SimData".

  `Runtime` "MainProg_NoReneg.f90": `16 minutes \& 9 seconds`

  `Runtime` "MainProg_Reneg.f90": `16 minutes \& 54 seconds`

  (b) Compile and run the Fortran program "Simulation.f90". The program can be compiled and run by executing the batch file "runsim.bat". This generates the statistics used to construct one section of Table 4 in the appendix.

  `Runtime` "Simulation.f90": `5 seconds`

- "12. Sensitivity_for_eta"

  This contains three subfolders:

  1. Programs to solve and simulate the model after setting $\eta = 0.4$.
  2. Programs to solve and simulate the model after setting $\eta = 0.6$.
  3. Programs to solve and simulate the model after setting $\eta = 1.0$.

  To run these programs we follow these steps:

(a) Compile and run the Fortran program "MainProg_NoReneg.f90". Then compile and run the Fortran program "MainProg_Reneg.f90". The two programs can be compiled and run by executing the batch file "run.bat". Running the program will generate and save data in subfolder "SimData".

    `Runtime` "MainProg_NoReneg.f90": `16 minutes \& 9 seconds`

    `Runtime` "MainProg_Reneg.f90": `16 minutes \& 54 seconds`

(b) Compile and run the Fortran program "Simulation.f90". The program can be compiled and run by executing the batch file "runsim.bat". This generates the statistics used to construct Table 5 in the appendix.

    `Runtime` "Simulation.f90": `5 seconds`

These programs also generate the data used to construct Table 9 in the online appendix.

- "13. Sensitivity_for_lambda"

  This contains two subfolders:

  1. Programs to solve and simulate the model after setting $\lambda = 0.12$.
  2. Programs to solve and simulate the model after setting $\lambda = 0.16$.

  To run these programs we follow these steps:

  (a) Compile and run the Fortran program "MainProg_NoReneg.f90". Then compile and run the Fortran program "MainProg_Reneg.f90". The two programs can be compiled and run by executing the batch file "run.bat". Running the program will generate and save data in subfolder "SimData".

    `Runtime` "MainProg_NoReneg.f90": `16 minutes \& 9 seconds`

    `Runtime` "MainProg_Reneg.f90": `16 minutes \& 54 seconds`

  (b) Compile and run the Fortran program "Simulation.f90". The program can be compiled and run by executing the batch file "runsim.bat". This generates the statistics used to construct one section of Table 4 in the appendix.

    `Runtime` "Simulation.f90": `5 seconds`

- "14. Sensitivity_for_mu"

  This contains two subfolders:

  1. Programs to solve and simulate the model after setting $\mu = 1.0$.
  2. Programs to solve and simulate the model after setting $\mu = 1.5$.

  To run these programs we follow these steps:

  (a) Compile and run the Fortran program "MainProg_NoReneg.f90". Then compile and run the Fortran program "MainProg_Reneg.f90". The two programs can be compiled and run by executing the batch file "run.bat". Running the program will generate and save data in subfolder "SimData".

    `Runtime` "MainProg_NoReneg.f90": `16 minutes \& 9 seconds`

    `Runtime` "MainProg_Reneg.f90": `16 minutes \& 54 seconds`

(b) Compile and run the Fortran program "Simulation.f90". The program can be compiled and run by executing the batch file "runsim.bat". This generates the statistics used to construct one section of Table 4 in the appendix.

`Runtime` "Simulation.f90": `5 seconds`

- "15. Sensitivity_for_varrho^R"

This contains two subfolders:

1. Programs to solve and simulate the model after setting $\varrho^R = 0.85$.
2. Programs to solve and simulate the model after setting $\varrho^R = 0.95$.

To run these programs we follow these steps:

(a) Compile and run the Fortran program "MainProg_NoReneg.f90". Then compile and run the Fortran program "MainProg_Reneg.f90". The two programs can be compiled and run by executing the batch file "run.bat". Running the program will generate and save data in subfolder "SimData".

`Runtime` "MainProg_NoReneg.f90": `16 minutes \& 9 seconds`

`Runtime` "MainProg_Reneg.f90": `16 minutes \& 54 seconds`

(b) Compile and run the Fortran program "Simulation.f90". The program can be compiled and run by executing the batch file "runsim.bat". This generates the statistics used to construct one section of Table 4 in the appendix.

`Runtime` "Simulation.f90": `5 seconds`

- "15. Sensitivity_for_wgt_ent"

This contains three subfolders:

1. Programs to solve and simulate the model after setting $\Psi = 0.06$.
2. Programs to solve and simulate the model after setting $\Psi = 0.16$.
3. Programs to solve and simulate the model after setting $\Psi = 0.20$.

To run these programs we follow these steps:

(a) Compile and run the Fortran program "MainProg_NoReneg.f90". Then compile and run the Fortran program "MainProg_Reneg.f90". The two programs can be compiled and run by executing the batch file "run.bat". Running the program will generate and save data in subfolder "SimData".

`Runtime` "MainProg_NoReneg.f90": `16 minutes \& 9 seconds`

`Runtime` "MainProg_Reneg.f90": `16 minutes \& 54 seconds`

(b) Compile and run the Fortran program "Simulation.f90". The program can be compiled and run by executing the batch file "runsim.bat". This generates the statistics used to construct one section of Table 4 in the appendix.

`Runtime` "Simulation.f90": `5 seconds`

“4. EXTENDED MODEL WITH RANDOM PARTICIPATION - Online Appendix”

The folder contains two subfolders

- “1. Program_With_Recalibration”

  This folder contains the Fortran programs to solve and simulate the extended model with random participation in foreign financial markets. It also contains the Gauss program to replicate the welfare gains graph in the online appendix. To run these programs we follow these steps:

  (a) Compile and run the Fortran program “MainProg_NoReneg.f90”. Then compile and run the Fortran program “MainProg_Reneg.f90”. The two programs can be compiled and run by executing the batch file “run.bat”. Running the program will generate and save data in subfolder “SimData”.

  `Runtime` “MainProg_NoReneg.f90”: `20 minutes \& 53 seconds`

  `Runtime` “MainProg_Reneg.f90”: `21 minutes \& 18 seconds`

  (b) Compile and run the Fortran program “Simulation.f90”. The program can be compiled and run by executing the batch file “runsim.bat”. This generates the statistics used to construct Table 1 and 3 in the online appendix. Running the program will also save data in subfolder “PlotData” that we will use to replicate the welfare gain graph for the online appendix.

  `Runtime` “Simulation.f90”: `7 seconds`

  (d) We now open subfolder “PlotData” and run the GAUSS program to construct the welfare gains graph for the online appendix. Gauss program “Welfare_Gains_Plot.gau” replicates Figure 3 in the online appendix. Figure 2 is the same as the one presented in the paper.

  `Runtime` “Welfare_Gains_Plot.gau”: `3 seconds`

- “2. Program_Without_Recalibration”

  This folder contains the programs to solve, simulate the extended model with random participation in foreign financial markets. The difference is that we do not recalibrate the model but we use the same parameters as the ones used in the baseline model. To run these programs we follow these steps:

  (a) Compile and run the Fortran program “MainProg_NoReneg.f90”. Then compile and run the Fortran program “MainProg_Reneg.f90”. The two programs can be compiled and run by executing the batch file “run.bat”. Running the program will generate and save data in subfolder “SimData”.

  `Runtime` “MainProg_NoReneg.f90”: `19 minutes \& 7 seconds`

  `Runtime` “MainProg_Reneg.f90”: `20 minutes \& 10 seconds`

  (b) Compile and run the Fortran program “Simulation.f90”. The program can be compiled and run by executing the batch file “runsim.bat”. This generates the statistics used to construct Table 4 in the online Appendix.

  `Runtime` “Simulation.f90”: `6 seconds`

References

[1] Bruegel database of sovereign bond holdings developed in Merler and Pisani-Ferry (2012). https://www.bruegel.org/dataset/sovereign-bond-holdings

[2] European Central Bank, Statistical Data Warehouse, Balance Sheet Items. https://sdw.ecb.europa.eu/browseExplanation.do?node=1491

[3] Federal Reserve Economic Data (FRED), Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/

[4] Global Financial Data. https://globalfinancialdata.com.

[5] Merler, S. and J. Pisani-Ferry (2012) "Who's Afraid of Sovereign Bonds". *Bruegel Policy Contribution* 2012-02.

[6] Mitchener, K. J. and Trebesch, C. (2021). "Sovereign Debt in the 21st Century: Looking Backward, Looking Forward". *NBER Working Paper Series* No. 28598. National Bureau of Economic Research.