# ReadMe for Replicating

# A Bayesian Multifactor Spatio-Temporal Model for Estimating Time-Varying Network Interdependence [1]

Licheng Liu  Xun Pang

## Computational platforms

1. We tested our code on an MacBook Pro 2021 with Apple M1 Pro chip and 16G RAM. The operation system is MacOS 12.0.1 (Monterey).

2. The R version is 4.1.2.

## Installing packages

1. Please install packages "Rcpp" (≥1.0.7), "RcppArmadillo" (≥ 0.10.7.5.0), "ggplot2" (≥3.3.5), "coda" (≥0.19-4), "MASS" (≥7.3-55), "abind" (≥1.4-5), "mvtnorm" (≥1.1-3), "ggstance" (≥0.3.5), "stargazer" (≥5.2.2), "igraph" (≥ 1.2.11), "mcmcr" (≥ 0.6.1), "foreign" (≥ 0.8-82), "gridExtra" (≥ 2.3), from CRAN.

2. Please install "bpNet" (0.0.4) from tar.gz files from the "package" folder, for example, in Mac/Linux command lines:
   ```
   > R CMD INSTALL bpNet_0.0.4.tar.gz
   ```

3. Please check this page if you encounter an installation error, such as the "-lgfortran" error. For installation problems related to MacOS Big Sur, you may find this website useful.

## Folders and their functionalities

| | |
|---|---|
| code | Stores code files required to simulate and plot data, and summarize results |
| data | Stores simulation and empirical data |
| plots | Stores graphs from code files |
| log | Stores logs of running code files |
| package | Stores R package `bpNet` |

## Notes

[1] Please contact Licheng Liu (liulch@mit.edu) if you have any questions related to replication.

1. Please make sure to set path to the root replication folder `PSRMReplicationLP` in R.

2. Only code files with an integer index need to be executed to replicate the results in the main text as well as appendix. For convenience, we create the code file "0_master.R", which is the only code file to be executed for replication. Code files without an integer index are supporting functions for simulated data generating or visualization. To speed things up, you can execute the files in parallel.

3. All graphics are saved in the "plots" folder. When you run the code, existing files in these folders will be overwritten, which is normal.

4. All logs are saved in the "log" folder. When you run the code, existing files in these folders will be overwritten, which is normal.

5. When checking the replication results, please refer to the final version of the paper and the online appendix to get correct numberings of figures and tables (in the final revision, we adjusted the sequence of figures in the appendix and took off the figures of network visualizations, which we deem not necessary).

6. Figure 1, Tables 1 and 2 present the identification problem, the simulation design, and comparisons with other methods; Figure A10(a) is a figure directly copied and pasted from Chaudoin, Milner and Pang (2015); Table A2 provides variable names and definitions. Replication is not applicable to these figures and tables (Figures 1 and A10 (a); Tables 1, 2, and A2).

7. Certain results may not be exactly republicated due to randomness of the simulation processes. Especially, the true values of the AR(1) $\rho_t$ in the simulation studies are randomly generated, and the true and estimated trajectories of time-varying interdependence are likely to be different based on different simulation datasets generated with our code. To get the exact results needs to use the simulation datasets on which the reported results are based, stored in the folder *DataSim*. The code to execute the simulation analysis calls these data by default. You can also generate new datasets using the code `SimData.R` and the stored simulated datasets will be updated with the newly generated datasets in the same folder.

**Mapping file names to Figures appearing in the paper**

All figures are stored in the `plots` folder, and figures in different analyses are in different sub-folders as stated in the "In Folder" columns in the tables below.

*1. Figures in Simulation Studies*

*1.1. In the Main Text*

| In Paper | In Folder | File Name | In Paper | In Folder | File Name |
|---|---|---|---|---|---|
| Figure 2 (a)-left | sim1cor3 | rho1.pdf | Figure 4 (a)-left | sim2cor3 | rho5.pdf |
| Figure 2 (a)-middle | sim1cor6 | rho1.pdf | Figure 4 (a)-middle | sim2cor6 | rho5.pdf |
| Figure 2 (a)-right | sim1cor9 | rho1.pdf | Figure 4 (a)-right | sim2cor9 | rho5.pdf |
| Figure 2 (b)-left | sim1cor3 | rho2.pdf | Figure 4 (b)-left | sim2cor3 | rho6.pdf |
| Figure 2 (b)-middle | sim1cor6 | rho2.pdf | Figure 4 (b)-middle | sim2cor6 | rho6.pdf |
| Figure 2 (b)-right | sim1cor9 | rho2.pdf | Figure 4 (b)-right | sim2cor9 | rho6.pdf |
| Figure 2 (c)-left | sim1cor3 | rho3.pdf | Figure 4 (c)-left | sim2cor3 | rho7.pdf |
| Figure 2 (c)-middle | sim1cor6 | rho3.pdf | Figure 4 (c)-middle | sim2cor6 | rho7.pdf |
| Figure 2 (c)-right | sim1cor9 | rho3.pdf | Figure 4 (c)-right | sim2cor9 | rho7.pdf |
| Figure 2 (d)-left | sim1cor3 | rho4.pdf | Figure 4 (d)-left | sim2cor3 | rho8hist.pdf |
| Figure 2 (d)-middle | sim1cor6 | rho4.pdf | Figure 4 (d)-middle | sim2cor6 | rho8hist.pdf |
| Figure 2 (d)-right | sim1cor9 | rho4.pdf | Figure 4 (d)-right | sim2cor9 | rho8hist.pdf |
| Figure 3 (a) | sim1cor9 | factor1.pdf | Figure 5 (a) | sim3 | rho2.pdf |
| Figure 3 (b) | sim2cor9 | factor2.pdf | Figure 5 (b)-i | sim3 | rho4.pdf |
| | | | Figure 5 (b)-ii | sim3 | rho4hist.pdf |

*1.2. In the Online Appendix (OA)*

| In OA | In Folder | File Name | In OA | In Folder | File Name |
|---|---|---|---|---|---|
| Study I | | | | | |
| Figure A1-(a) | sim1cor9 | beta1.pdf | Figure A2 (a) | sim1cor9 | kappa1.pdf |
| Figure A1-(b) | sim1cor9 | beta2.pdf | Figure A2 (b) | sim1cor9 | rhoA11.pdf |
| Figure A1-(c) | sim1cor9 | beta3.pdf | Figure A2 (c) | sim1cor9 | rhoA12.pdf |
| Figure A1-(d) | sim1cor9 | beta4.pdf | Figure A3 | sim1cor9 | error1.pdf |
| Study II | | | | | |
| Figure A4-(a) | sim2cor9 | beta5.pdf | Figure A5 (a) | sim2cor9 | kappa2.pdf |
| Figure A4-(b) | sim2cor9 | beta6.pdf | Figure A5 (b) | sim2cor9 | rhoA21.pdf |
| Figure A4-(c) | sim2cor9 | beta7.pdf | Figure A5 (c) | sim2cor9 | rhoA22.pdf |
| Figure A4-(d) | sim2cor9 | beta8.pdf | Figure A6 | sim2cor9 | error2.pdf |
| Study III | | | | | |
| Figure A7 | sim3 | factor1.pdf | | | |
| Additional Simulation Study: MLST-MF and SAOM | | | | | |
| Figure A15 | sim_saom | sim_saom_factor.pdf | Figure A16 | sim_saom | sim_saom_rho.pdf |

*2. Figures in Empirical Studies*

*2.1. In the Main Text*

| In Paper | In Folder | File Name | In Paper | In Folder | File Name |
|---|---|---|---|---|---|
| Figure 6 (a) | MIG | RhoMF.pdf | Figure 7 (a) | WTO | RhoMF.pdf |
| Figure 6 (b) | MIG | RhoFE.pdf | Figure 7 (b) | WTO | RhoFE.pdf |
| Figure 6 (c) | MIG | RhoCon.pdf | Figure 7 (c) | WTO | RhoCon.pdf |

*2.2. In the Online Appendix (OA)*

| In OA | In Folder | File Name | In OA | In Folder | File Name |
|---|---|---|---|---|---|
| Migration and Terrorism | | | | | |
| Figure A8 | MIG | factorsMF.pdf | Figure A9 upper-left | MIG | beta1.pdf |
| Figure A9 upper-right | MIG | beta2.pdf | Figure A9 lower-left | MIG | beta3.pdf |
| Figure A9 lower-right | MIG | beta4.pdf | | | |
| WTO and Free Trade | | | | | |
| Figure A10 (b) | WTO | RhoMF230.pdf | Figure A11 | WTO | factors.pdf |
| Figure A12 | WTO | factorslog.pdf | Figure A13 | WTO | factorslogCon.pdf |
| Figure A14 left | WTO | beta2.pdf | Figure A14 middle | WTO | beta1.pdf |
| Figure A14 right | WTO | beta3.pdf | | | |
| Additional Example: Human Rights and Trade Network | | | | | |
| Figure A17 | HR | hr_factor.pdf | Figure A18 | HR | hr_rhot.pdf |

### Code files

0. 0_master.R

   - Description: Sets working directory and executives all code files for replication.
   - Output: Results in the main text and appendix.

1. 1_block_sim3.R

   - Description: Performs analysis on simulated datasets `sim1cor3.RData` and `sim2cor3.RData` in simulation Study I and Study II
   - Output: Figures in folder sim1cor3: `rho1.pdf, rho2.pdf, rho3.pdf, rho4.pdf`; Figures in folder sim2cor3: `rho5.pdf, rho6.pdf, rho7.pdf, rho8hist.pdf`

2. 2_block_sim6.R

   - Description: Performs analysis on simulated datasets `sim1cor6.RData` and `sim2cor6.RData`
   - Output: Figures in folder sim1cor6: `rho1.pdf, rho2.pdf, rho3.pdf, rho4.pdf`; Figures in folder sim2cor6: `rho5.pdf, rho6.pdf, rho7.pdf, rho8hist.pdf`

3. 3_block_sim9.R

   - Description: Performs analysis on simulated datasets `sim1cor9.RData` and `sim2cor9.RData`

- Output: Figures in folder sim1cor9: `rho1.pdf, rho2.pdf, rho3.pdf, rho4.pdf, beta1.pdf, beta2.pdf,beta3.pdf,beta4.pdf, error1.pdf, factor1.pdf, kappa1.pdf, rhoA11, rhoA12`; Figures in folder sim2cor9: `rho5.pdf, rho6.pdf, rho7.pdf, rho8hist.pdf, beta5.pdf, beta6.pdf,beta7.pdf,beta8.pdf, error2.pdf, factor2.pdf, kappa2.pdf, rhoA21, rhoA22`

4. 4_icew_sim.R

   - Description: Performs analysis on simulated datasets `sim3.RData` in simulation Study III
   - Output: Figures in folder sim3: `rho2.pdf, rho4.pdf, rho4hist.pdf, factor1.pdf`

5. 5_WTOReplication.R

   - Description: Performs empirical analysis "WTO and Free Trade" using replication data `tradewlag.csv`, `WTOdensity.csv`, and `WmWTOlist.Rdata`
   - Output: Figures in folder WTO: `RhoMF.pdf, RhoFE.pdf, RhoCon.pdf, factorslog.pdf, factorslogCon.pdf`; Table A3 in the online appendix.

6. 6_WTOReplicationIntial.R

   - Description: Performs initial analysis "WTO and Free Trade" without taking log of the outcome variable, using replication data `tradewlag.csv`, `WTOdensity.csv`, and `WmWTOlist.Rdata`
   - Output: Figures in folder WTO: `factors.pdf, RhoMF230.pdf`

7. 7_MigrationReplication.R

   - Description: Performs empirical analysis "Migration and Terrorism" using replication data `immigrationData.csv`, `terrorZ1.csv`, and `W_flow.Rdata`
   - Output: Figures in folder MIG: `RhoMF.pdf, RhoFE.pdf, RhoCon.pdf, factorMF.pdf`; Table A1 in the online appendix.

8. 8_bloc_sim_saom.R

   - Description: Performs analysis on the simulation study in Section A.4.1, Online Appendix (to compare MLST-MF and SAOM)
   - Output: Figures in folder sim3: `sim_saom_factor.pdf, sim_saom_rhot.pdf`

9. 9_replications_dangerious_liaisons.R

- Description: Performs empirical analysis "Human Rights and Trade Network" in Section A.4.2, online appendix, using replication data `bin_trade1_1984.dta` to `bin_trade1_2000.dta`, and `physint1.dta`
- Output: Figures in folder HR: `hr_factor.pdf, hr_rhot.pdf`

10. DataSim.R

    - Description: Generates datasets for simulation studies of Study I, Study II, and Study III
    - Output: simulated datasets in Folder SimData: `blockW.RData, icewsW.RData, sim1cor3.RData, sim1cor6.RData, sim1cor9.RData, sim2cor3.RData, sim2cor6.RData, sim2cor9.RData, sim3.RData`

11. SaomDataSim.R

    - Description: Generates datasets for simulation studies in Section A.4.1, Online Appendix (to compare MLST-MF and SAOM)
    - Output: simulated datasets in Folder SimData: `saom_sim1.RData`

12. net_plot.R

    - Description: Provides functions to graphically summarize mcmc output

13. simulated20529.R

    - Description: Provides functions to `DataSim.R` to generate simulated data for Study I and Study II

14. simulated30529.R

    - Description: Provides functions to `DataSim.R` to generate simulated data for Study III

## References

Chaudoin, Stephen, Helen Milner and Xun Pang. 2015. "International Systems and Domestic Politics: Linking Complex Interactions with Empirical Models in International Relations." *International Organization* 69(2):275–309.