



The World Bank's MFMod Framework in Python with Modelflow

First Submission: RR_WLD_2024_01

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This review verifies the reproducibility of the exhibits included in the paper “*The World Bank's MFMod Framework in Python with Modelflow*”.

Contents in this review:

1. Main findings
2. List of exhibits and reproducibility status
3. Reproduction Environment

Main findings

- **The exhibits in the paper did not meet the requirements for computational reproducibility, with 18 out of 145 exhibits failing to reproduce accurately.**
- The code was successfully executed on a new computer after following the instructions of the README to install all required Python dependencies and configure Jupyter Notebook.
- The code takes approximately 20 minutes to run.
- We conducted our reproducibility analysis based on the book PDF file shared via OneDrive by the authors June 17, 2025.
- **Reproducibility Summary:**
 - **Data:** All data are included in the reproducibility package.
 - **Code:** All code files (from cleaning to analysis) are included in the reproducibility package.
 - **Outputs:** All outputs are generated by code included in the reproducibility package.
 - **Reproducibility verification:** Reviewers had access to the same materials in the public reproducibility package.
 - **Dependencies environment:** The reviewers created a new environment using the latest versions of dependencies available at the moment of the review.

List of exhibits and reproducibility status

Chapter 1

No exhibits are included in this section.

Chapter 2

No exhibits are included in this section.

Chapter 3

No exhibits are included in this section.

Chapter 4

No exhibits are included in this section.

Chapter 5

No exhibits are included in this section.

Chapter 6

No exhibits are included in this section.

Chapter 7

- Section 7.4.5 Figure 1 (p. 60) Reproduced.
- Section 7.4.5 Figure 2 (p. 60) Reproduced.
- Section 7.4.5 Figure 3 (p. 61) Reproduced.

Chapter 8

No exhibits are included in this section.

Chapter 9

- Section 9.3.2 Figure 1 (p. 89) Reproduced.
- Section 9.3.3 Figure 1 (p. 92) Reproduced.
- Section 9.4.5 Table 1 (p. 95) Reproduced.
- Section 9.4.5 Table 2 (p. 96) Reproduced.
- Section 9.4.5 Table 3 (p. 97) Reproduced.

Chapter 10

- Section 10.5.4 Figure 1 (p. 104) Reproduced.
- Section 10.5.4 Table 1 (p. 105) Reproduced.

Chapter 11

- Section 11.2.1 Figure 1 (p. 111) Reproduced.
- Section 11.2.1 Figure 2 (p. 112) Reproduced.
- Section 11.2.2 Figure 1 (p. 114) Reproduced.
- Section 11.2.3 Figure 1 (p. 116) Reproduced.
- Section 11.2.3 Figure 2 (p. 117) Reproduced.
- Section 11.2.4 Figure 1 (p. 118) Reproduced.
- Section 11.2.5 Figure 1 (p. 122) Reproduced.
- Section 11.3 Figure 1 (p. 124) Reproduced.

Chapter 12

- Section 12.4.1 Figure 1 (p. 129) Reproduced.
- Section 12.5 Figure 1 (p. 131) Reproduced.
- Section 12.6.2 Figure 1 (p. 136) Reproduced.

Chapter 13

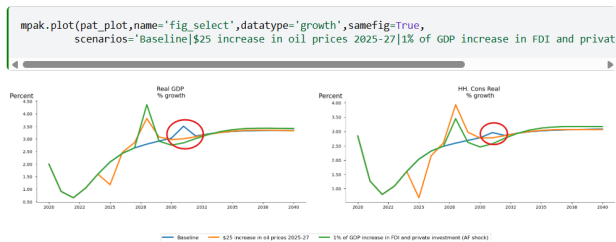
- Section 13.4.5 Figure 1 (p. 142) Reproduced.
- Section 13.4.5 Figure 2 (p. 143) Reproduced.
- Section 13.4.5 Figure 3 (p. 143) Reproduced.
- Section 13.4.5 Figure 4 (p. 144) Reproduced.
- Section 13.4.5 Figure 5 (p. 144) Reproduced.
- Section 13.4.5 Figure 6 (p. 145) Reproduced.
- Section 13.4.5 Figure 7 (p. 145) Reproduced.
- Section 13.4.5 Figure 8 (p. 145) Reproduced.
- Section 13.7.1 Figure 1 (p. 150) Reproduced.
- Section 13.7.1 Figure 2 (p. 151) Reproduced.
- Section 13.7.1 Figure 3 (p. 151) Reproduced.
- Section 13.8 Figure 1 (p. 153) Reproduced.
- Section 13.8 Figure 2 (p. 153) Reproduced.

Chapter 14

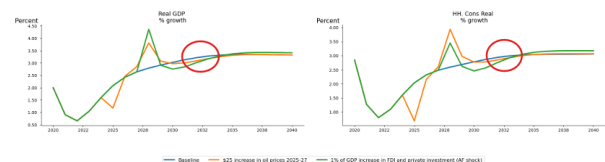
- Section 14.2.2 Table 1 (p. 160) Reproduced.

- Section 14.2.4 Table 1 (p. 164) Reproduced.
- Section 14.2.4 Table 2 (p. 164) Reproduced.
- Section 14.2.4 Table 3 (p. 165) Reproduced.
- Section 14.2.4 Table 4 (p. 166) Reproduced.
- Section 14.4 Figure 1 (p. 173) Reproduced.
- Section 14.4 Figure 2 (p. 174) Reproduced.
- Section 14.4.2 Figure 1 (p. 175) Reproduced.
- Section 14.4.2 Figure 2 (p. 176) Reproduced.
- Section 14.4.2 Figure 3 (p. 176) Reproduced.
- Section 14.4.5 Figure 1 (p. 179) Reproduced.
- Section 14.4.6 Figure 1 (p. 179) Reproduced.
- Section 14.4.6 Figure 2 (p. 180) Reproduced.
- Section 14.4.7 Figure 1 (p. 181) Does not Reproduce. Difference highlighted below.

Code

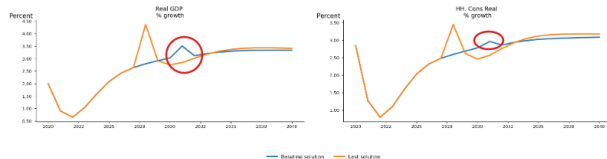


Paper

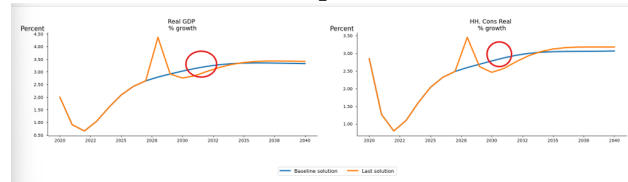


- Section 14.4.7 Figure 2 (p. 181) Does not Reproduce. Difference highlighted below.

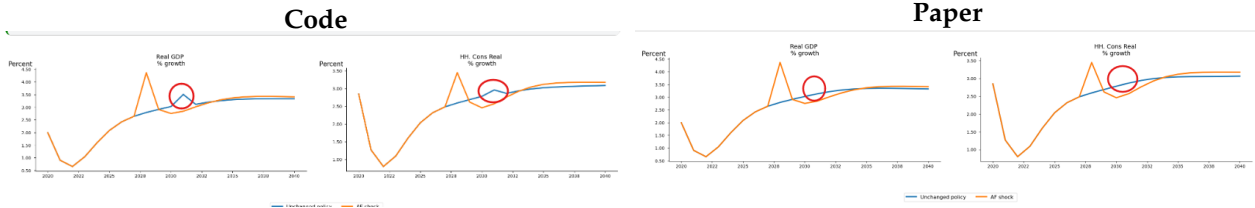
Code



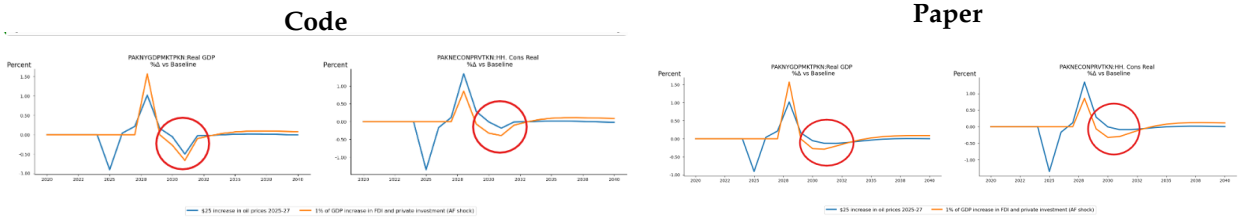
Paper



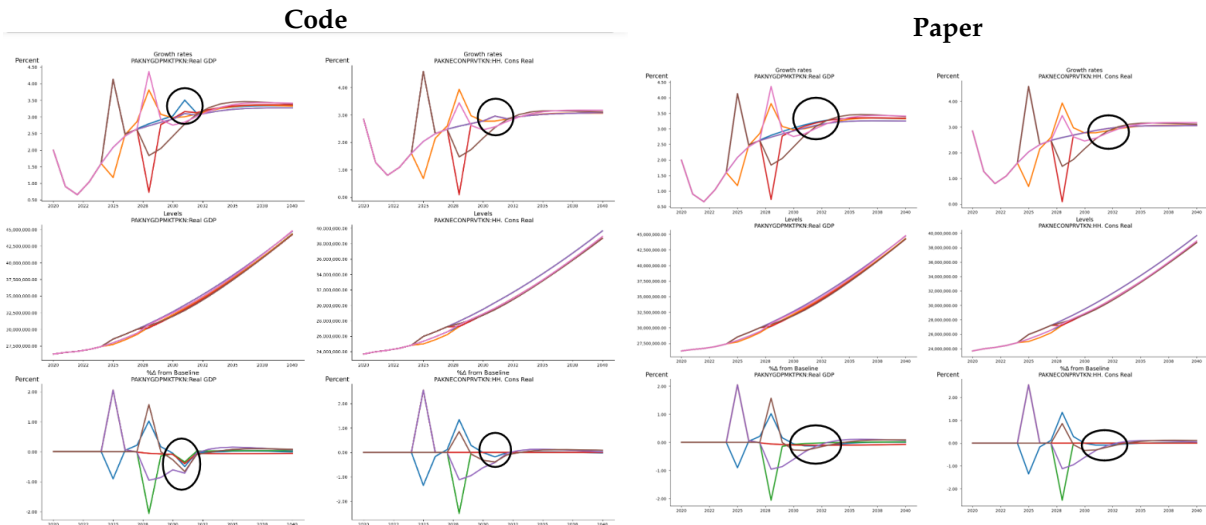
- Section 14.4.7 Figure 3 (p. 182) **Does not Reproduce**. Difference highlighted below.



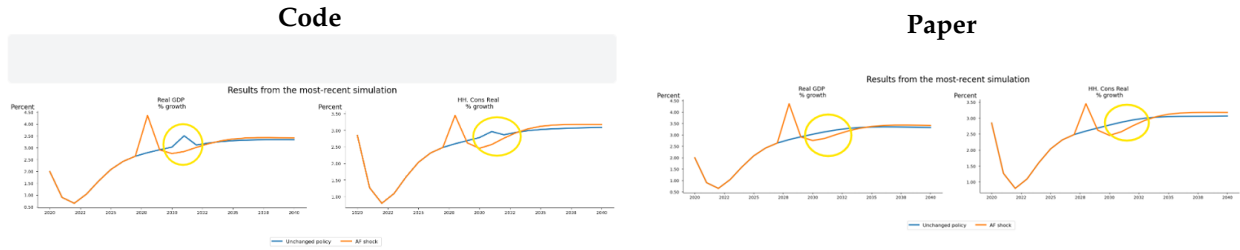
- Section 14.4.8 Figure 1 (p. 183) **Does not Reproduce**. Difference highlighted below.



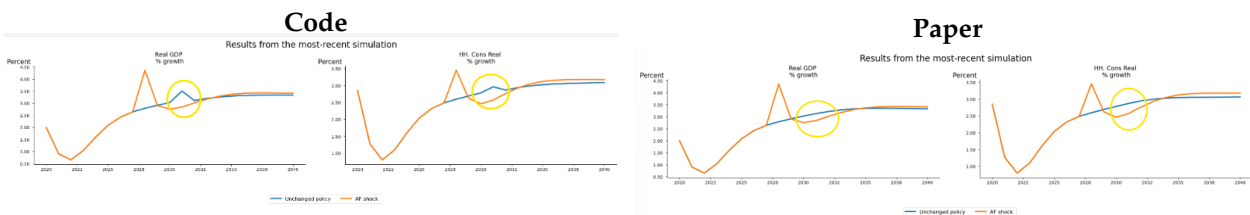
- Section 14.4.9 Figure 1 (p. 184) **Does not Reproduce**. Difference highlighted below.



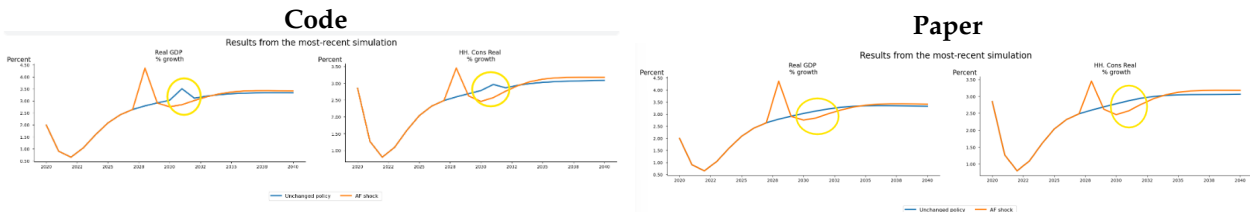
- Section 14.6.2 Figure 1 (p. 189) **Does not Reproduce**. Difference highlighted below.



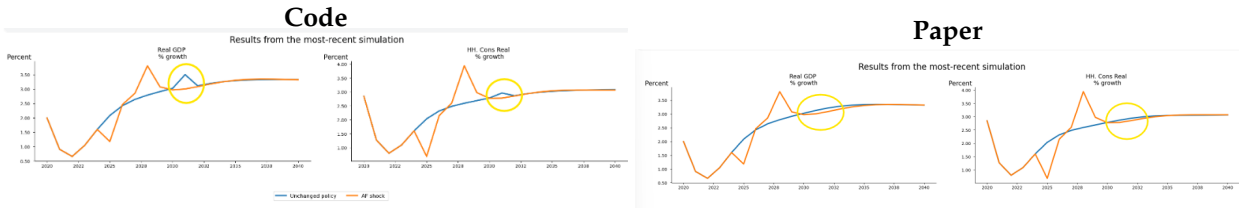
- Section 14.6.2 Figure 2 (p. 190) **Reproduced**.
- Section 14.6.2 Table 1 (p. 190) **Reproduced**.
- Section 14.6.3 Figure 1 (p. 191) **Reproduced**.
- Section 14.6.3 Figure 2 (p. 192) **Reproduced**.
- Section 14.6.3 Table 1 (p. 192) **Reproduced**.
- Section 14.7.2 Figure 1 (p. 195) **Does not Reproduce**. Difference highlighted below.



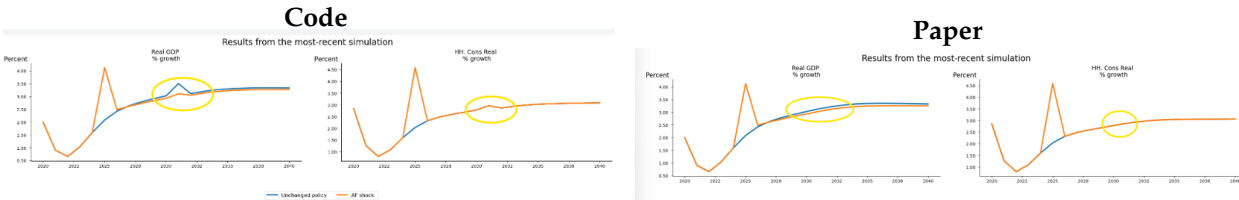
- Section 14.7.3 Figure 1 (p. 195) **Does not Reproduce**. Difference highlighted below.



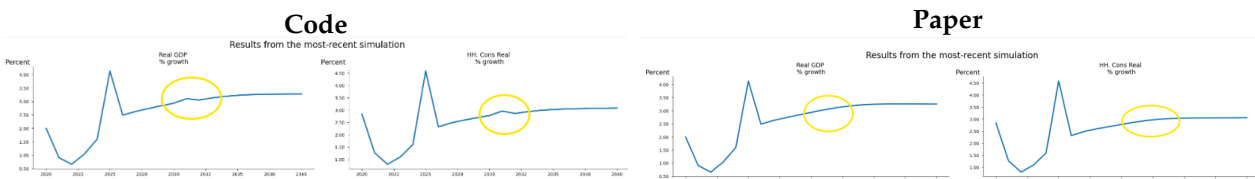
- Section 14.7.3 Figure 2 (p. 195) **Does not Reproduce**. Difference highlighted below.



- Section 14.7.3 Figure 3 (p. 195) **Does not Reproduce**. Difference highlighted below.



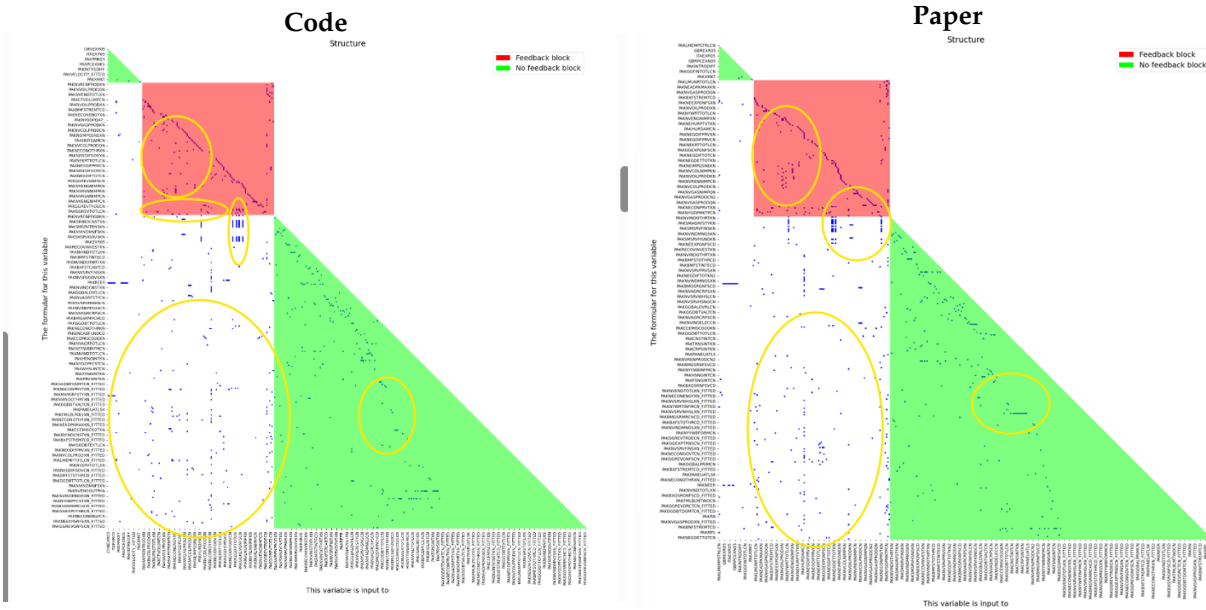
- Section 14.7.4 Figure 1 (p. 197) **Does not Reproduce**. Difference highlighted below.



- Section 14.8 Figure 1 (p. 198) **Reproduced**.
- Section 14.8 Figure 2 (p. 199) **Reproduced**.
- Section 14.9.1 Figure 1 (p. 199) **Reproduced**.

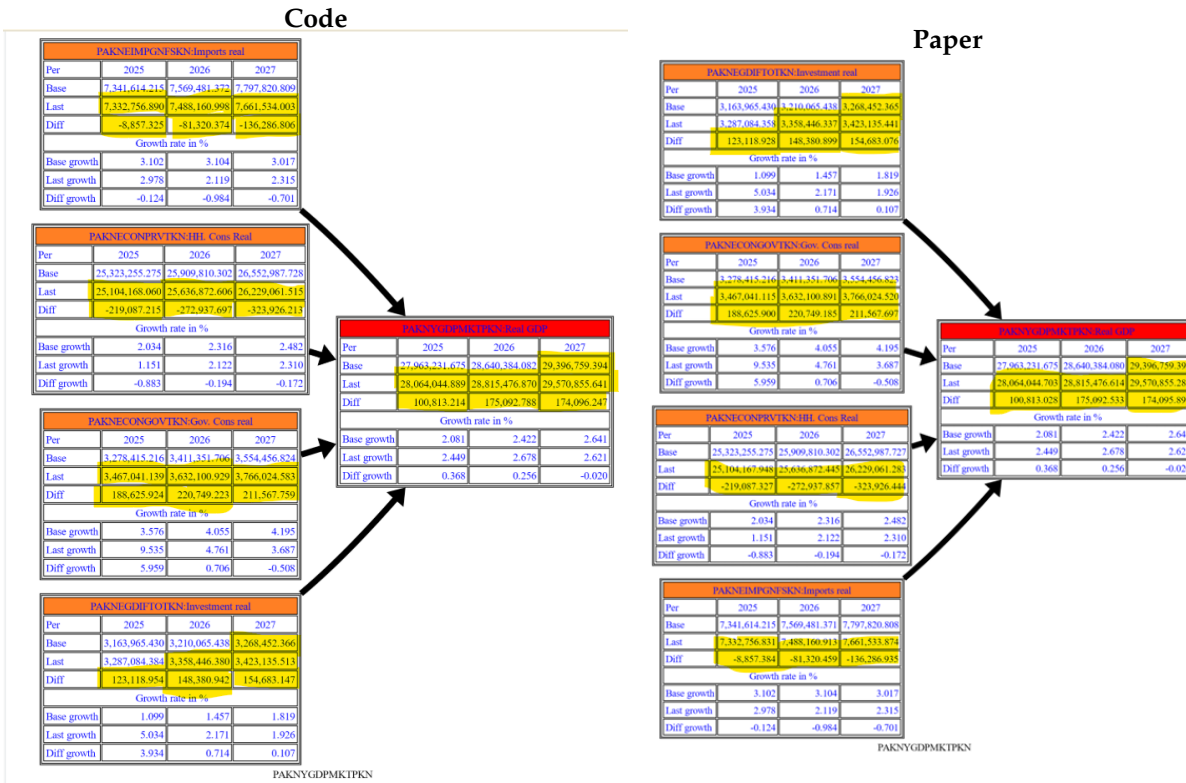
Chapter 15

- Section 15.3 Figure 1 (p. 205) **Does not Reproduce**. Difference highlighted below.



- Section 15.4 Figure 1 Does not Apply.
- Section 15.4.1 Figure 1 (p. 208) **Reproduced**.
- Section 15.4.2 Figure 2 (p. 209) Does not Apply.
- Section 15.4.3 Figure 1 (p. 210) Does not Apply.
- Section 15.4.4 Figure 1 (p. 210) Does not Apply.

- Section 15.4.4 Table 1 (p. 212) Does not Reproduce. Difference highlighted below. Additionally, the order in which the tables appear is different but that does not impact reproducibility.



- Section 15.4.5 Figure 1 (p. 213) Does not Apply.
- Section 15.4.6 Figure 1 (p. 214) Does not Apply.

Chapter 16

- Section 16.4 Table 1 (p. 218) Reproduced.
- Section 16.4 Table 2 (p. 219) Does not Reproduce. Difference highlighted below.

Code						Paper					
Formula : FRML <IDENT> PAKCEMISCO2TKN = PAKCEMISCO2CKN+PAKCEMISCO2OKN+PAKCEMISCO2GKN						Formula : FRML <IDENT> PAKCEMISCO2TKN = PAKCEMISCO2CKN+PAKCEMISCO2OKN+PAKCEMISCO2GKN					
		2024	2025	2026	2027			2024	2025	2026	2027
Variable	lag					Variable	lag				
Base	0	230370296.29	236240661.89	242537407.87	248995663.43	Base	0	230370296.30	236240661.90	242537407.88	248995663.44
Alternative	0	230370296.29	183872958.98	190234947.64	196979000.45	Alternative	0	230370296.30	183872958.70	190234948.29	196979001.74
Difference	0	0.00	-52367702.91	-52302460.23	-52016662.98	Difference	0	0.00	-52367703.20	-52302459.59	-52016661.70
Percent	0	-0.00	-22.17	-21.56	-20.89	Percent	0	-0.00	-22.17	-21.56	-20.89
Contributions to difference for PAKCEMISCO2TKN						Contributions to difference for PAKCEMISCO2TKN					
		2024	2025	2026	2027			2024	2025	2026	2027
Variable	lag					Variable	lag				
PAKCEMISCO2CKN	0	0.00	-22807769.47	-22763631.12	-22643892.98	PAKCEMISCO2CKN	0	0.00	-22807769.52	-22763630.99	-22643892.74
PAKCEMISCO2OKN	0	0.00	-13105360.55	-13576630.32	-13868114.84	PAKCEMISCO2OKN	0	0.00	-13105360.72	-13576629.92	-13868114.05
PAKCEMISCO2GKN	0	0.00	-16454572.89	-15962198.79	-15504655.15	PAKCEMISCO2GKN	0	0.00	-16454572.96	-15962198.68	-15504654.91
Share of contributions to difference for PAKCEMISCO2TKN						Share of contributions to difference for PAKCEMISCO2TKN					

- Section 16.4 Table 3 (p. 220) Does not Reproduce. Similar simulation to above and differences are repeated.
- Section 16.4 Table 4 (p. 220) Does not Reproduce. Difference highlighted below.

Code						Paper					
		2024	2025	2026	2027			2024	2025	2026	2027
Variable	lag					Variable	lag				
PAKCEMISCO2CKN	0	NaN	43.55	4.35e+01	4.35e+01	PAKCEMISCO2CKN	0	NaN	43.55	4.35e+01	4.35e+01
PAKCEMISCO2GKN	0	NaN	31.42	3.05e+01	2.98e+01	PAKCEMISCO2GKN	0	NaN	31.42	3.05e+01	2.98e+01
PAKCEMISCO2OKN	0	NaN	25.03	2.60e+01	2.67e+01	PAKCEMISCO2OKN	0	NaN	25.03	2.60e+01	2.67e+01
Total	0	0.0	100.00	1.00e+02	1.00e+02	Total	0	0.0	100.00	1.00e+02	1.00e+02
Residual	0	-100.0	0.00	1.14e-13	5.68e-14	Residual	0	-100.0	0.00	5.68e-14	-4.26e-14

- Section 16.4 Table 5 (p. 221) Reproduced.
- Section 16.4 Table 6 (p. 221) Reproduced.
- Section 16.5 Table 1 (p. 223) Reproduced.
- Section 16.5.1 Table 1 (p. 224 & 225) Reproduced.
- Section 16.6.1 Table 1 (p. 226) Reproduced.
- Section 16.6.2 Table 1 (p. 227) Reproduced.
- Section 16.6.4 Table 1 (p. 228) Reproduced.
- Section 16.6.5 Table 1 (p. 228) Reproduced.
- Section 16.6.5 Table 2 (p. 230) Reproduced.
- Section 16.6.5 Table 3 (p. 230) Reproduced.

- Section 16.6.5 Table 4 (p. 230) Reproduced.
- Section 16.6.6 Figure 1 (p. 231) Reproduced.
- Section 16.6.6 Figure 2 (p. 232) Reproduced.
- Section 16.6.7 Table 1 (p. 232) Reproduced.
- Section 16.7 Figure 1 (p. 234) Does not Apply.
- Section 16.8 Table 1 (p. 235) Reproduced.
- Section 16.8 Table 2 (p. 236) Reproduced.
- Section 16.8 Figure 1 (p. 236) Reproduced. The order of components in the figure is different in the html file but that does not jeopardize reproducibility.
- Section 16.9 Figure 1 (p. 237) Reproduced.
- Section 16.10 Figure 1 (p. 238) Reproduced.
- Section 16.10 Figure 2 (p. 239) Reproduced.
- Section 16.11 Figure 1 (p. 240) Reproduced.
- Section 16.12.3 Figure 1 (p. 242) Reproduced.
- Section 16.12.4 Figure 1 (p. 243) Reproduced.
- Section 16.12.5 Figure 1 (p. 245) Reproduced.
- Section 16.12.5 Figure 2 (p. 245) Reproduced.
- Section 16.12.6 Figure 1 (p. 246) Reproduced.
- Section 16.12.6 Figure 2 (p. 246) Reproduced.
- Section 16.12.7 Figure 1 (p. 247) Reproduced.
- Section 16.12.8 Figure 1 (p. 248) Reproduced.
- Section 16.13.1 Figure 1 (p. 249) Reproduced.
- Section 16.13.2 Figure 1 (p. 250) Reproduced.
- Section 16.13.3 Table 1 (p. 250 & 251) Reproduced.
- Section 16.13.3 Figure 2 (p. 252) Reproduced.

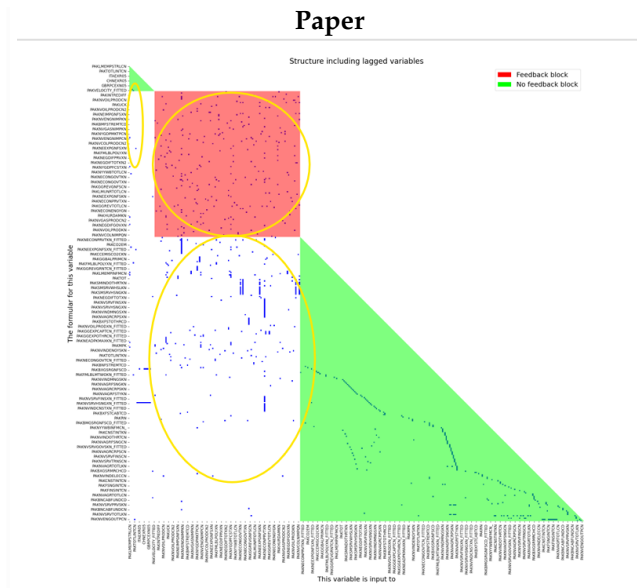
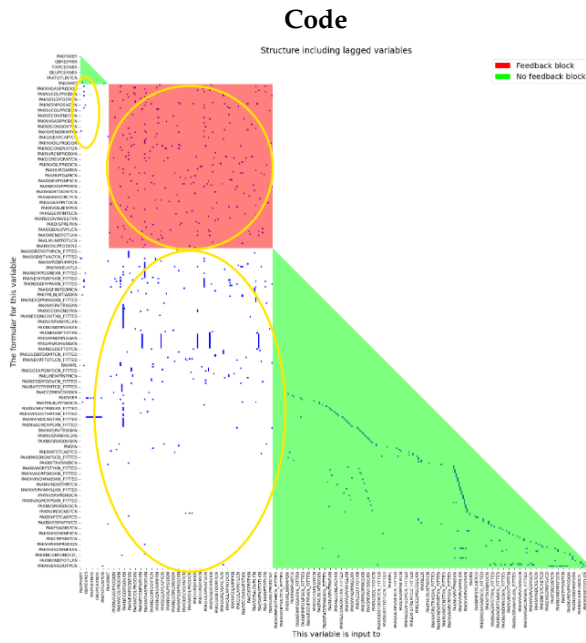
Chapter 17

No exhibits are included in this section.

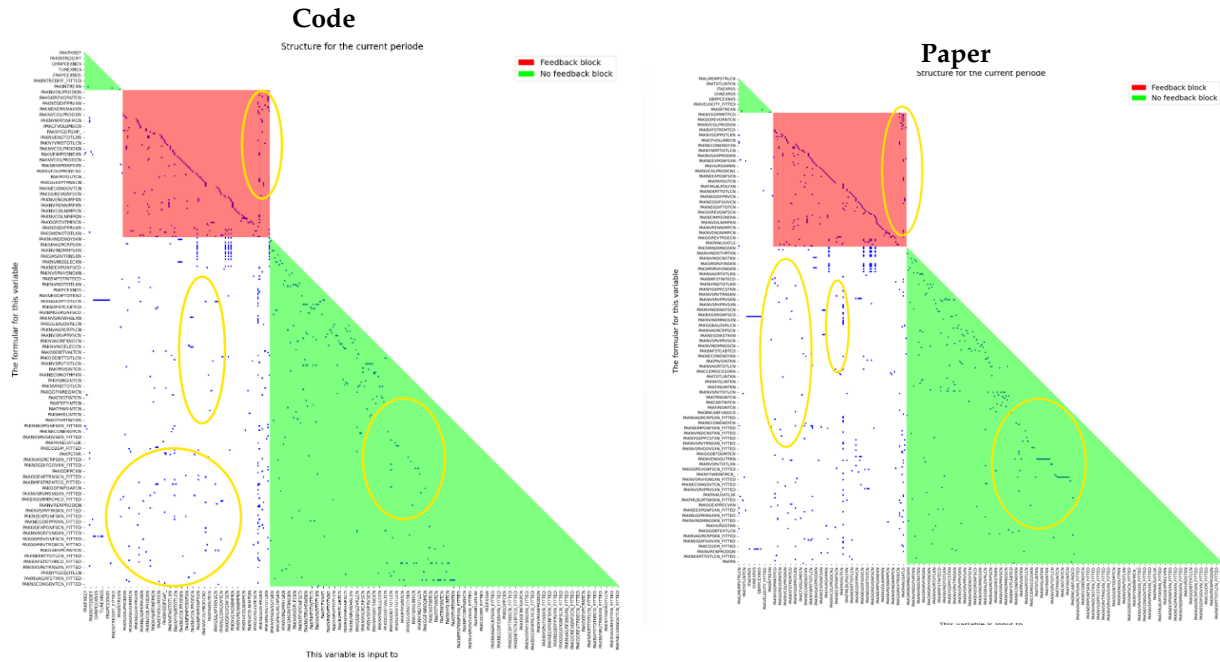
Chapter 18

- Section 18.6.3 Figure 1 (p. 268) Reproduced.

- Section 18.13 Figure 1 (p. 279) **Does not Reproduce**. Difference highlighted below.



- Section 18.13 Figure 2 **Does not Reproduce**. Difference highlighted below.



- Section 18.15.7 Figure 1 (p. 287) **Reproduced**.
- Section 18.16.1 Figure 1 (p. 290) **Reproduced**.
- Section 18.16.2 Figure 1 (p. 292) **Reproduced**.
- Section 18.16.7 Figure 1 (p. 294) **Reproduced**.
- Section 18.16.8 Figure 1 (p. 294) **Reproduced**.
- Section 18.16.9 Figure 1 (p. 295) **Reproduced**.
- Section 18.16.10 Figure 1 (p. 295) **Reproduced**.
- Section 18.17 Figure 1 (p. 296) **Reproduced**.
- Section 18.17.1 Figure 1 (p. 298) **Reproduced**.
- Section 18.18 Figure 1 (p. 299) **Reproduced**.
- Section 18.19 Figure 1 (p. 299) **Reproduced**.
- Section 18.19.1 Figure 1 (p. 300) **Reproduced**.
- Section 18.19.2 Figure 1 (p. 301) **Reproduced**.
- Section 18.19.3 Figure 1 (p. 302) **Reproduced**.
- Section 18.20.1 Figure 1 (p. 303) **Does not Apply**.
- Section 18.20.1 Figure 2 (p. 304) **Does not Apply**.

- **Section 18.20.2 Figure 1 (p. 305)** **Reproduced.** The order of components in the figure is different in the html file but that does not jeopardize reproducibility.
- **Section 18.21.1 Table 1 (p. 306)** **Reproduced.** We found a few differences within ± 0.01 between the html file and the manuscript. We attribute this to rounding and do not consider that they affect the reproducibility of the results.
- **Section 18.21.1 Table 2 (p. 307)** **Reproduced.** We found a few differences within ± 0.01 between the html file and the manuscript. We attribute this to rounding and do not consider that they affect the reproducibility of the results.
- **Section 18.21.2 Figure 1 (p. 311)** **Reproduced.**
- **Section 18.23 Figure 1 (p. 313)** **Reproduced.**

Reproduction Environment

Paper exhibits were reproduced on two computers with the following specifications:

- Computer 1:
 - OS: Windows 11 Enterprise
 - Processor: Intel(R) Xeon(R) Platinum 8562Y+ 2.80 GHz (2 processors)
 - Memory available: 32 GB
 - Software version: Python 3.12.6
- Computer 2:
 - OS: Windows 11 Enterprise
 - Processor: Intel(R) Xeon(R) Platinum 8562Y+ 2.80 GHz (4 processors)
 - Memory available: 32 GB
 - Software version: Python 3.12.6