Core Model Proposal #410: Updates to Socioeconomic and Macroeconomic Data, Processing Structure, and Visualization

Product: Global Change Analysis Model (GCAM)

Institution: Joint Global Change Research Institute (JGCRI)

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Related sectors: Economy

Type of development: Data

Purpose: This Core Model Proposal (CMP) comprehensively restructures and updates the macroeconomic and socioeconomic modules in gcamdata. It includes visualizations of key data inputs, accounting identities, and data flows in the context of GCAM-Macro-KLEM. Major improvements include: (1) updating the Penn World Table (PWT) to version 10 and incorporating a new source, the Global Macro Database (GMD); (2) updating the SSP socioeconomics database from version 3.0.1 to 3.2; (3) introducing SSP-specific differentiation of employment and labor force data; (4) improving data integration between national accounts (from PWT, GMD, and GTAP) and GDP/population data from external sources; and (5) general data cleaning and structural refinements. We document the data sources and key assumptions used throughout the processing. These updates establish the foundation for the forthcoming KLEAM version of GCAM-macro.

Contents

1. Introduction

Socioeconomic drivers such as population and GDP play a central role in shaping future global economic and multisectoral dynamics in GCAM. In partial equilibrium models with dynamic trajectories, including GCAM, future changes in population and GDP are typically treated as exogenous and are often based on projections from the Shared Socioeconomic Pathways (SSP) database (https://data.ece.iiasa.ac.at/ssp). Since GCAM version 7.0, a macroeconomic module (the KLEM version) has been incorporated into the model, as detailed in Core Model Proposal (CMP)-332 (Patel et al., 2023). Specifically, a "Materials" sector was introduced to represent the rest of the economy (including household and government activity), enabling GCAM to endogenously calculate GDP. This endogenous GDP, in turn, feeds back into sectoral models through income elasticities.

To maintain consistency with externally specified SSP trajectories in the reference scenario, the total factor productivity (TFP) parameters in the Materials sector's constant elasticity of substitution (CES) production function are calibrated to reconcile the resulting GDP with the SSP projections. When the model structure or input data are updated, the TFP must be recalibrated. For example, in the recent SSP database update documented in CMP-399 (Zhao et al., 2024), considerable adjustments were required in the recalibrated TFP values.

More recently, GCAM v8.0 and CMP-404 (Patel et al., 2025) updated GCAM's base year from 2015 to 2021. While the TFP values were recalibrated, the underlying data required for GCAM-Macro were not fully updated; in some cases, they were simply extrapolated (e.g., PWT v9 data extended from 2017 to 2021). In addition, several outstanding bug fixes remained unresolved. These issues underscored the need for a comprehensive review of data flows within the socioeconomic and macroeconomic modules, which had become outdated and poorly organized.

This CMP, building on previous developments (CMPs 332, 399, & 404), presents a comprehensive restructuring and update of data processing within the macroeconomic and socioeconomic components of *gcamdata*, implemented in a traceable and transparent manner. We take this opportunity to visualize key data inputs into GCAM-Macro and to more clearly document the datasets, assumptions, and accounting identities underpinning the KLEM framework. These improvements aim to enhance user understanding of GCAM-Macro and its outputs, thereby facilitating broader adoption and application. They also lay the foundation for the forthcoming KLEAM version of GCAM-Macro.

2. Overview of key changes in gcamdata

The key data and code changes implemented in GCAM and gcamdata are summarized in **Table 1**. Previously, the socioeconomic modules and their associated data processing were not well organized or consistently maintained. In this CMP, we have fully restructured the socioeconomic modules to improve the traceability and transparency of data flows. The revised data processing flows are summarized in **Table 2**. In total, 19 socioeconomic modules were revised, including 3 XML-exporting modules (further

highlighted in **Table 3**). A schematic of the main data flows across these modules, along with key processing notes, is provided in **Figure 1**.

Key updates include:

- **SSP Database Updated to v3.2 from v3.0.1**: Incorporates previously omitted regions and corrects known bugs not addressed in BYU 2021.
- **Transition from PWT v9 to v10** (Feenstra et al., 2015): Moves from data ending in 2017 to 2019; significant structural changes required a comprehensive reassessment of data usage.
- **Integration of the Global Macro Database (GMD)** (Müller et al., 2025): Added for nominal GDP decomposition and exchange rates. Complements FAOSTAT, which remains the main GDP source for consistency. Note that the main GDP from FAOSTAT was also converted to 2021 USD using regional GDP deflators now (not USA deflators)
- **Modular Reorganization of Data Processing**: New dedicated modules introduced for SSP data, GTAP, national accounts, and population to improve structure and maintainability.
- **Improved Data Integration**: Enhanced consistency and traceability between national accounts (PWT, GMD, GTAP) and external GDP/population data (FAOSTAT, SSP).
- **Introduction of SSP-Specific Labor/Employment Data**: Employment and labor force data are now differentiated by SSP, improving consistency with future socioeconomic assumptions. Additionally, the definition of the working-age population is improved in the mapping file.
- **Refined Savings-Income Relationship**: Simplified construction of savings behavior; cleaned up processing by relying on historical saving rates and parameter inputs. Future exploration is needed to improve these parameters.
- **Consistent Population Handling**: Population is now processed similarly to GDP, with a unified dataset (*L101.Pop_thous_Scen_R_Y*) covering both historical and future years (like *L102.gdp_mil90usd_Scen_R_Y*).
- **Legacy Data/Processing Removed**: Obsolete GCAM3 GDP and population inputs are fully eliminated.
- **New Income Elasticity Module**: *module_socio_IncomeElasticity_xml* consolidates income elasticity assumptions, primarily for industrial sectors. Documentation and expansion to other sectors are ongoing.

Table 1 Key data and code changes made in gcamdata

Data file/R chunk	Changes made
socioeconomics	Remove GCAM3 related files. And remove unused elasticity files.
socioeconomics/GTAP	Include a sectoral mapping (GCAM_GTAP_sector_mapping_AgLU.csv) along with some naming updates.
socioeconomics/NationalAccounts	Include the new Global Macro Database dataset (GMD_2025_03.csv). Update related mapping files
socioeconomics/PWT	Remove PWT folder and move PWT v10 to the NationalAccounts folder.
socioeconomics/SSP	Update SSP database from v3.0.1 to v3.2. Improve work age population and labor force mapping.
ModelInterface_headers.txt generate_package_data.R	Header updates: the labor force share has been moved out of the NationalAccount header to enable SSP-specific differentiation.
constants.R	Update socioeconomics related constants. E.g., socioeconomics.SSP_DB_BASEYEAR <- 2025 (updated from 2020)
zaglu_L100.GTAP_downscale_ctry.R	Move GTAP related data processing to socioeconomic modules. This module can be removed later (when the old land rental profit calculation is dropped)
zenergy_L143.HDDCDD.R zenergy_L144.building_det_flsp.R zenergy_L223.electricity.R zenergy_L232.other_industry.R zenergy_L2321.cement.R zwater_L173.EFW_manufacturing.R	Remove “GCAM3” related dependencies and update the data use accordingly.
zenergy_L232.other_industry.R zenergy_L2321.cement.R	Improve income elasticity data flows.
zsocio_L100.GTAP.R zsocio_L100.SSP_database.R zsocio_L100.NationalAccounts.R	New modules to process source data
zsocio_L100.Population_hist.R	Renamed from zsocio_L100.Population_downscale_ctry
zsocio_L101.Population.R zsocio_L102.GDP.R	Improved structure and processing to stitch historical and future data.
zsocio_L201.Pop_GDP_scenarios.R zsocio_L281.macro_account_tracking.R	Improve data flows.
zsocio_L103.NationalAccounts.R zsocio_L203.NationalAccounts.R	Restructured based on zsocio_L180.GDP_macro.R and zsocio_L280.GDP_macro.R which were removed.
zsocio_xml_socioeconomics_IncomeElasticity.R zsocio_xml_socioeconomics_macro.R zsocio_xml_socioeconomics_SSP.R	Updated macro XML generating modules. Labor force shares are added to SSP scenarios now.
zsocio_xml_socioeconomics_IncomeElasticity.R configuration_ref.xml (all relevant configs)	A new module has been added to consolidate all income elasticity inputs into a single set of XML files (e.g., socioeconomics_incelas_SSP1.xml). The corresponding configuration files have also been updated accordingly.
zenergy_xml_aluminum_SSP.R zenergy_xml_cement_SSP.R zenergy_xml_chemical_SSP.R zenergy_xml_iron_steel_SSP.R zenergy_xml_Off_road_SSP.R zenergy_xml_other_industry_SSP.R zenergy_xml_paper_SSP.R zsocio_xml_bld_agg.R zsocio_L242.Bld_Inc_Elas_scenarios.R zsocio_L252.Trn_Inc_Elas_scenarios.R	Modules removed. These modules previously generated income elasticities by SSP—for example, aluminum_incelas_ssp1.xml—have been removed. These functionalities are now consolidated and processed through a new module under the socioeconomics system: zsocio_xml_socioeconomics_IncomeElasticity.R.

Table 2 Updated data flows in the socioeconomics modules in *gcamdata*

ID	Socioeconomics module	Module output
1	module_socio_L100.GDP_hist	L100.gdp_mil90usd_ctry_Yh
2	module_socio_L100.Population_hist	L100.Pop_thous_ctry_Yh
3	module_socio_L100.GTAP	L100.GTAP_capital_stock
4	module_socio_L100.SSP_database	L100.LaborForce_mil_SSP_ctry_Yfut_raw
		L100.Pop_thous_SSP_ctry_Yfut_raw
		L100.GDP_bilusd_SSP_ctry_Yfut_raw
5	module_socio_L100.NationalAccounts	L100.National_Accounts_GDP_Decomp_C_I_X_M_shares_R_Yh
		L100.National_Accounts_Metrics_R_Yh
		L100.National_Accounts_Employment_Share_POP_R_Yh
		L100.National_Accounts_Depreciation_Rate_R_Yh
		L100.National_Accounts_En_capital_inv_share_R_Yh
6	module_socio_L101.Population	L101.Pop_thous_R_Yh
		L100.Pop_thous_SSP_ctry_Yfut
		L101.Pop_thous_SSP_R_Yfut
		L101.Pop_thous_Scen_R_Y
7	module_socio_L102.GDP	L102.gdp_mil90usd_Scen_R_Y
		L102.pcgdp_thous90USD_Scen_R_Y
		L102.pcgdp_thous90USD_ctry_Yh
		L102.PPP_MER_R
8	module_socio_L103.NationalAccounts	L103.National_Accounts_mil90usd_R_Yh
		L103.LaborForceShare_Scen_R_Y
9	module_socio_L201.Pop_GDP_scenarios	L201.GDP_Scen
		L201.Pop_Scen
		L201.TotalFactorProductivity_Scen
		L201.LaborForceShare_Scen
		L201.PPPConvert
10	module_socio_L203.NationalAccounts	L203.NationalAccounts
		L203.SavingsRateParams
		L203.GDP_macro_function
		L203.FactorProductivity
11	module_socio_L281.macro_account_tracking	L281.BasePriceSectorMapping
		L281.GlobalTechAccountOutputUseBasePrice_fd
		L281.TrialValueResource
		L281.TechAccountOutput_entrade
		L281.TechAccountInput_entrade
		L281.TechAccountInput_NG_entrade
		L281.GlobalTechAccountInput_entrade
12	module_socio_L2323.iron_steel_Inc_Elas_scenarios	L2323.IncomeElasticity_iron_steel_Scen
13	module_socio_L2324.Off_road_Inc_Elas_scenarios	L2324.IncomeElasticity_Off_road_Scen
14	module_socio_L2325.chemical_Inc_Elas_scenarios	L2325.IncomeElasticity_chemical_Scen
15	module_socio_L2326.aluminum_Inc_Elas_scenarios	L2326.IncomeElasticity_aluminum_Scen
16	module_socio_L2327.paper_Inc_Elas_scenarios	L2327.IncomeElasticity_paper_Scen
17	module_socioeconomics_macro_xml	socioeconomics_macro.xml
18	module_socio_SSP_xml	socioeconomics_CORE.xml socioeconomics_SSPx.xml
19	module_socio_IncomeElasticity_xml	socioeconomics_incelas_sspx.xml

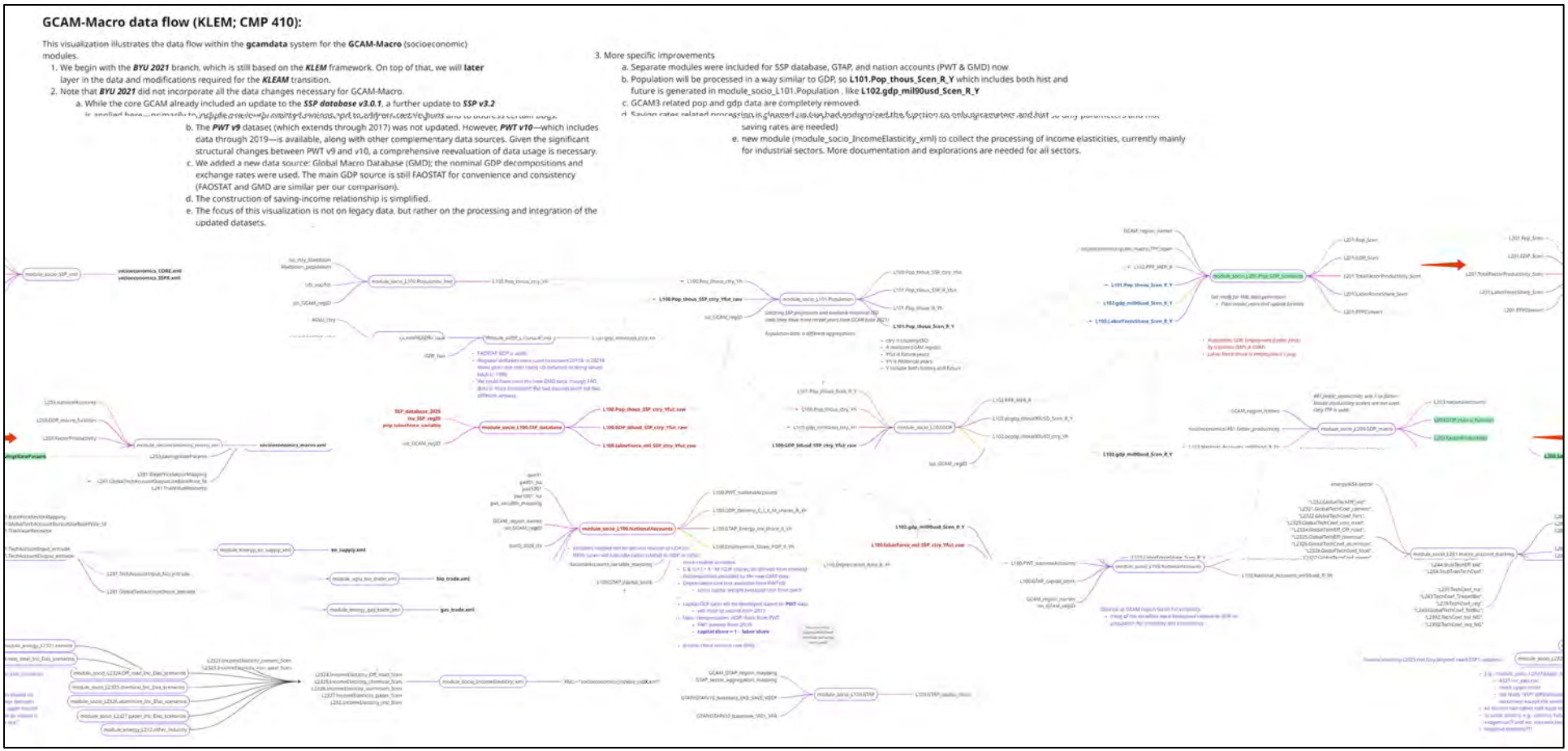


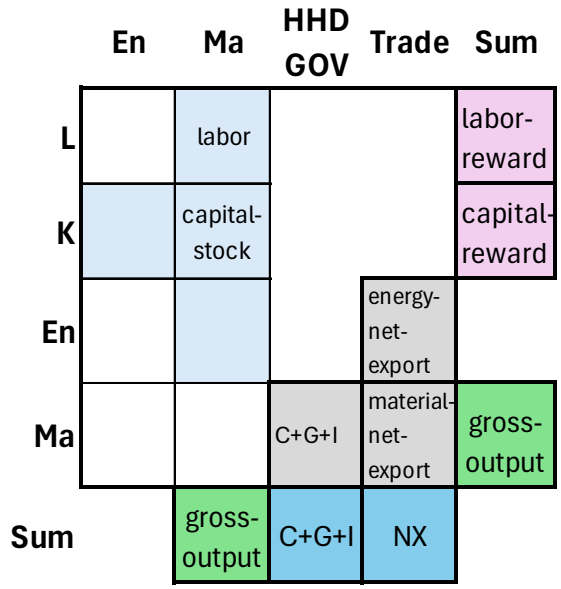
Fig. 1 Schematic of updated data flows in socioeconomics modules in gcamdata (a high-resolution PDF version provided on Confluence)

3. GCAM-Macro (KLEM) accounting identities, data inputs, and visualization

A summary of GCAM-Macro accounting identities in an input-output view is presented in **Fig. 2**, while the detailed structure of GCAM-Macro-KLEM has been documented in CMP-332 (Patel et al., 2023). This CMP enhances the overall data processing and quality for GCAM-Macro, establishing a stronger foundation for the forthcoming KLEAM development (which integrates agriculture into the KLEM framework). However, the calculation of energy capital investment, energy service aggregation, and their linkages to the macro module (as well as parameter uses) will be reviewed and documented in future work as part of the KLEAM integration.

Table 3 provides a more detailed summary of the socioeconomic data—specifically the three XML files—exported from gcamdata and used in GCAM. These represent the primary inputs for constructing the input-output framework of GCAM-Macro, as illustrated in **Fig. 2** (or alternatively, a Social Accounting Matrix). Additional variables are either derived from GCAM sectoral outputs or constructed based on available information. **Figs. 3–15** visualize these input data (see the "Fig/data source" column in **Table 3**). Detailed notes are added to figure captions. GCAM-Macro then extends these historical indicators into future periods using an internally consistent framework.

Note that in the figures, where relevant, Mexico is highlighted in regional panels as a reference, as it lies near the median among the 32 GCAM regions for key metrics such as population and per capita income. To aid region comparison, consistent gray y-axis ranges (based on the underlying data) are also included in regional panels, since axis scales may differ across panels and regions.



GDP decomposition by income:

GDP = labor-compensation + capital-compensation

GDP decomposition by expenditure:

GDP = C + G + I + NX

- gross-output (Ma supply) = Nested CES production function (L, K, En; TFP; elasticities)
- gross-output (Ma demand) = C + G + I + material-net-export

→ **GDP = gross-output + energy-net-export**

Materials production function

Nested constant elasticity of substitution (En, (L, K))

- En is an energy service index, linked to GCAM energy serivice inputs in final demand
- En is endogenous, aggregating energy serivces using initial prices as weights

Clearing capital/investment market

energy-investment + material-investment = savings + capital-net-export

- energy-investment: derived based on GCAM energy sectoral information
- capital-net-export: initially calibrated to -NX but being phased out to zero regionally (trade balance)
- savings = function(lagged savings-rate, per-capita GDP growth rate) x GDP
- material-investment = depreciation-rate x capital stock (beginning) + capital stock increase

Clearing labor market

Labor supply (employment linked to population) = Labor demand (material production input)

- all labor is currently placed in the Materials sector.

Fig. 2 GCAM-Macro-KLEM input-output framework and accounting identities

Table 3 GCAM input data in socioeconomics modules (XMLs). There are three socioeconomics XMLs needed in the configuration of GCAM.

XMLs	Variable/data	Periods	Fig/data source	Notes
socioeconomics_CORE.xml socioeconomics_SSP1.xml … socioeconomics_SSP5.xml	Demographics: population	**1975-2100**	Fig. 3; UN & SSP Database	Labor force is indeed "employed". TFP is the only difference between CORE and SSP2 in this XML.
	National Account: GDP	**1975-2100**	Fig. 4; FAOSTAT & SSP Database	
	National Account: labor-force-share	**1975-2100**	Fig. 5; UN & SSP Database	
	National Account: total-factor-productivity	2025-2100	Fig. 6; UN & SSP Database	
	gdp-ppp-conversion	2021	Fig. 7; UN & SSP Database	
socioeconomics_macro.xml	National Account: capital-stock	1975-2021	Fig. 8; PWT, FAOSTAT & GTAP	labor-wages (labor compensation/rewards) and capital-value (capital compensation/rewards) are for the Materials sector. Economy-wide depreciation rates are used in the Materials sector.
	National Account: depreciation-rate	**1975-2100**	Fig. 9; PWT	
	National Account: labor-wages	1975-2021	Fig. 10; PWT & FAOSTAT	
	National Account: capital-value	1975-2021	Fig. 11; PWT, FAOSTAT & GTAP	
	National Account: energy-investment	1975-2021	Fig. 12; GMD, FAOSTAT, GTAP	
	National Account: savings-rate	1975-2021	Fig. 13; GMD & FAOSTAT	
	National Account: capital-net-export	1975-2021	Fig. 14; GMD & FAOSTAT	
	Saving-rate-param			
	gdp-macro-function			
socioeconomics_incelas_ssp1.xml ... socioeconomics_incelas_ssp5.xml	energy-final-demand: income-elasticity	2025-2100	Fig.15; various sectoral assumptions	

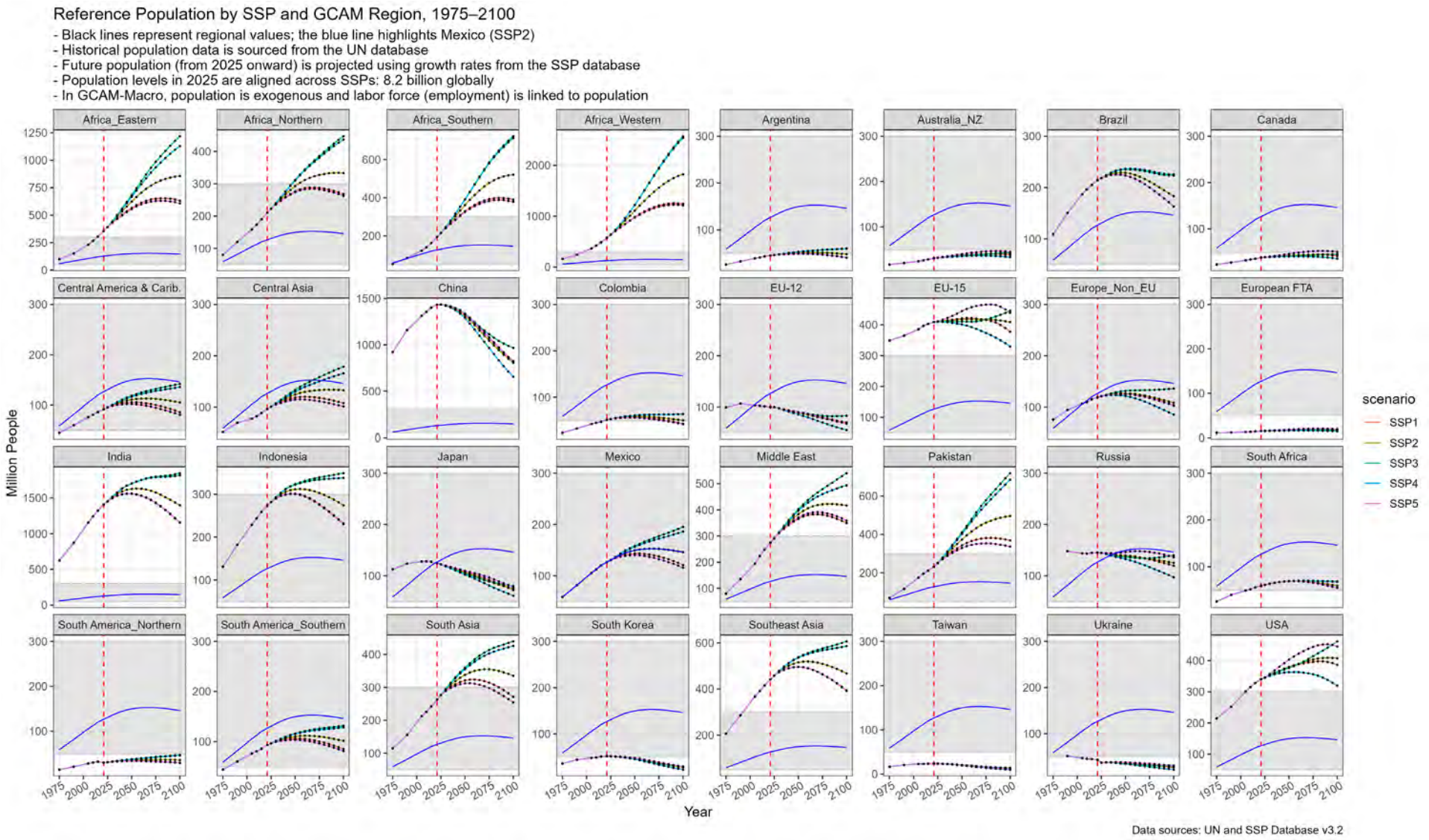


Fig. 3 Reference Population by SSP and GCAM Region, 1975 – 2100

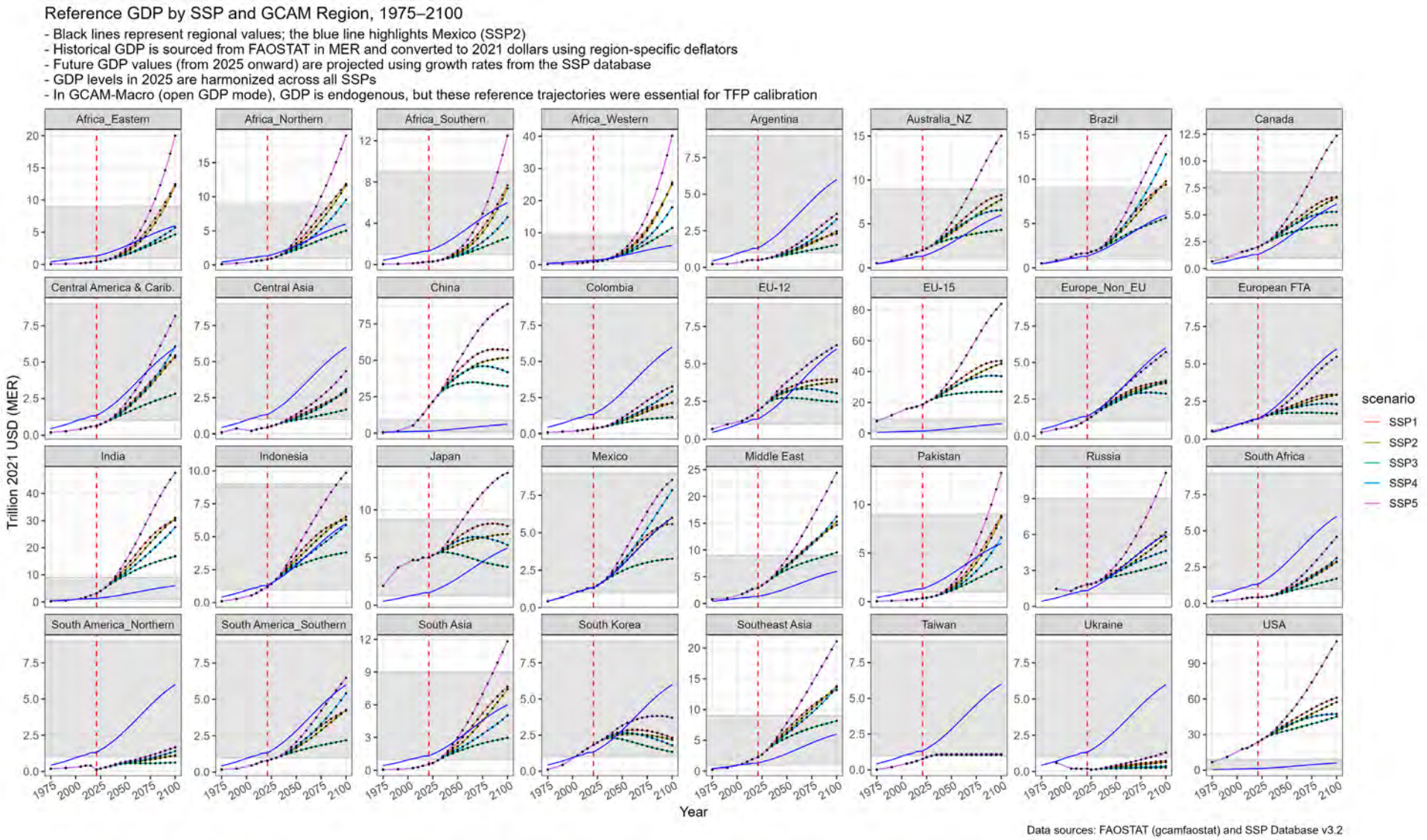


Fig. 4 Reference GDP by SSP and GCAM Region, 1975 – 2100

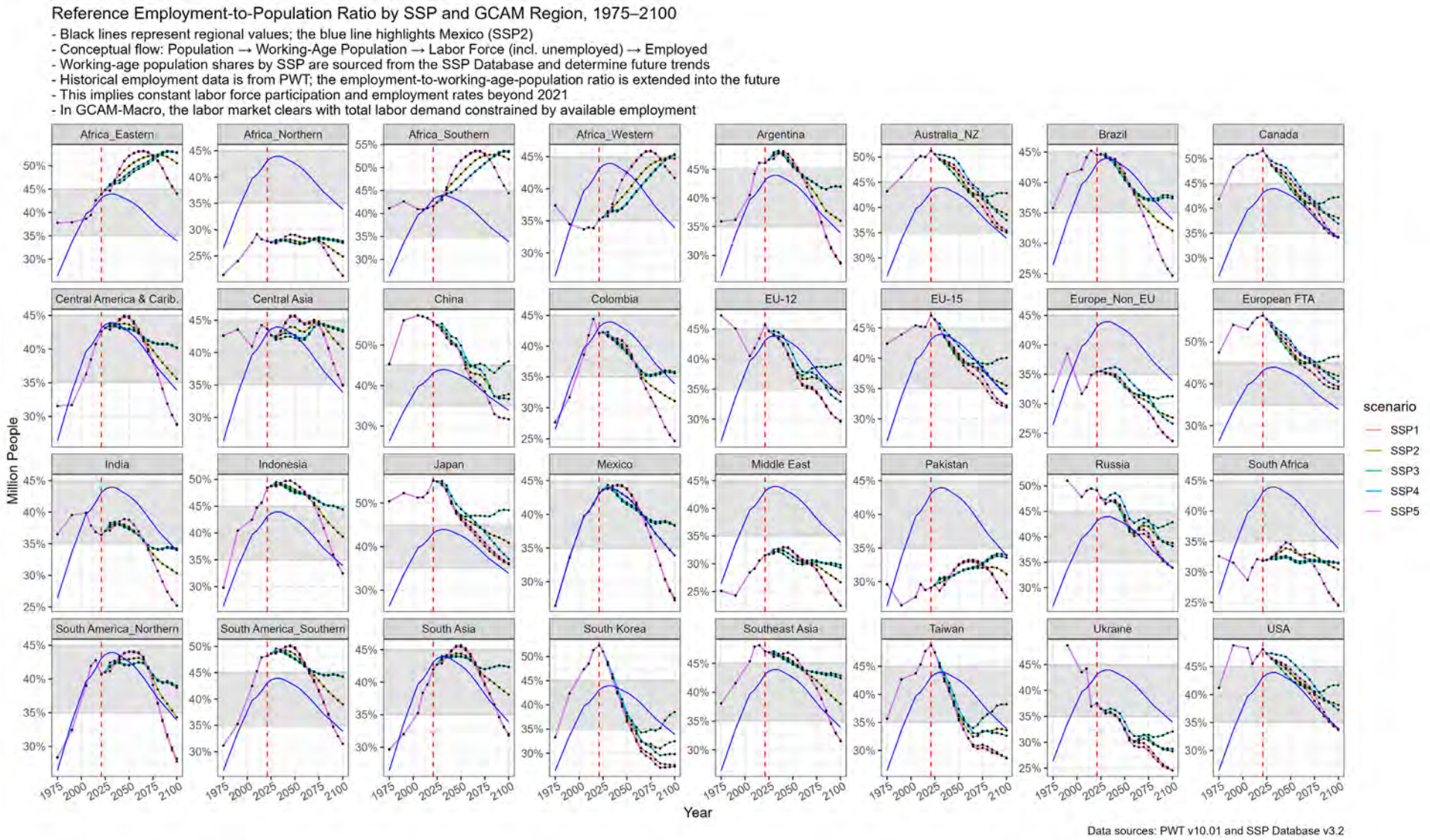


Fig. 5 Reference Employment-to-Population Ratio by SSP and GCAM Region, 1975 – 2100. A few regions currently have a large gender gap in employment, such as Northern Africa, the Middle East, and Pakistan. Future projections do not (yet) account for changes in this gender gap.

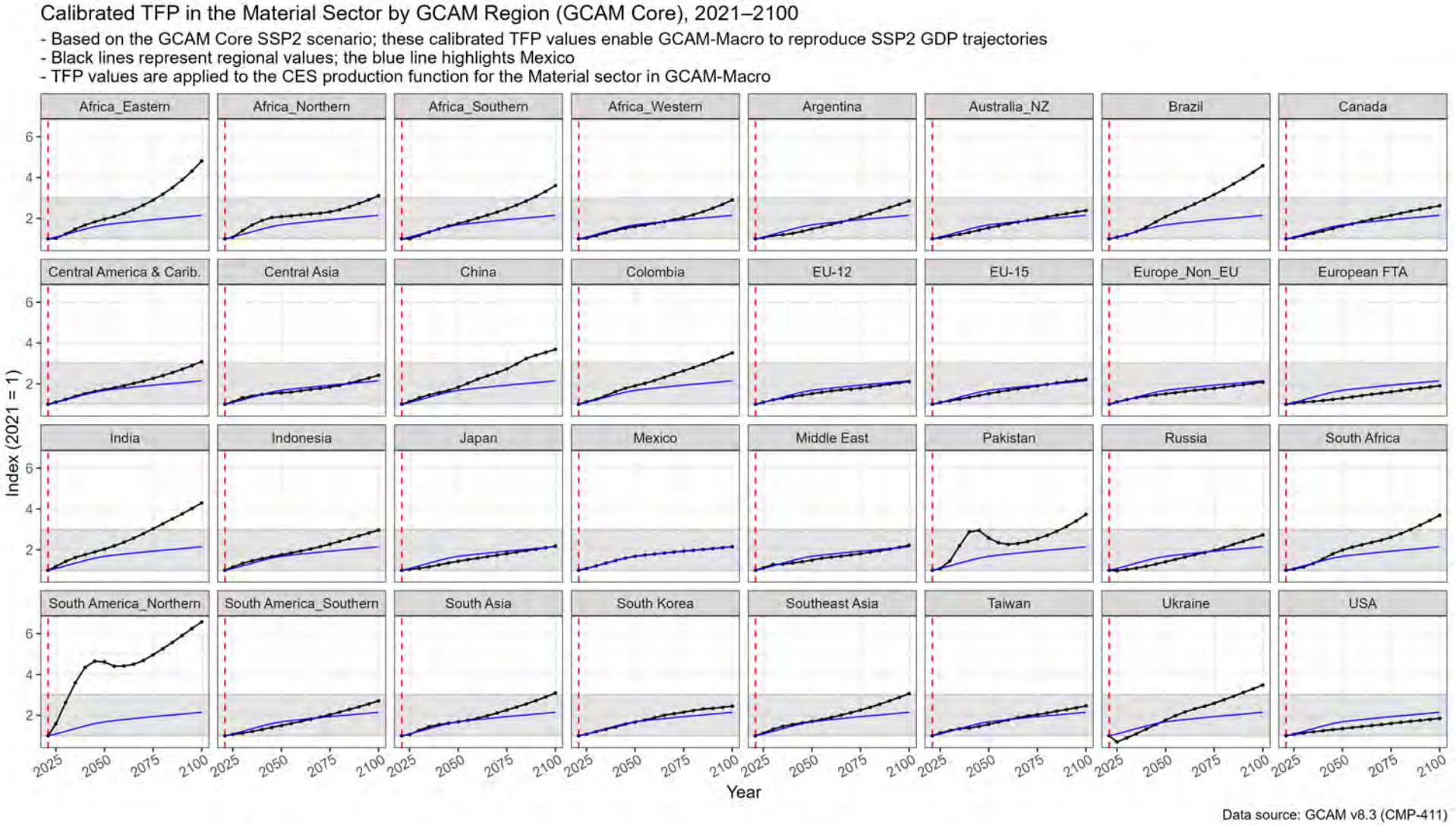


Fig. 6 Calibrated TFP in the Materials Sector by GCAM Region for the CORE GCAM scenario, 1975 – 2100

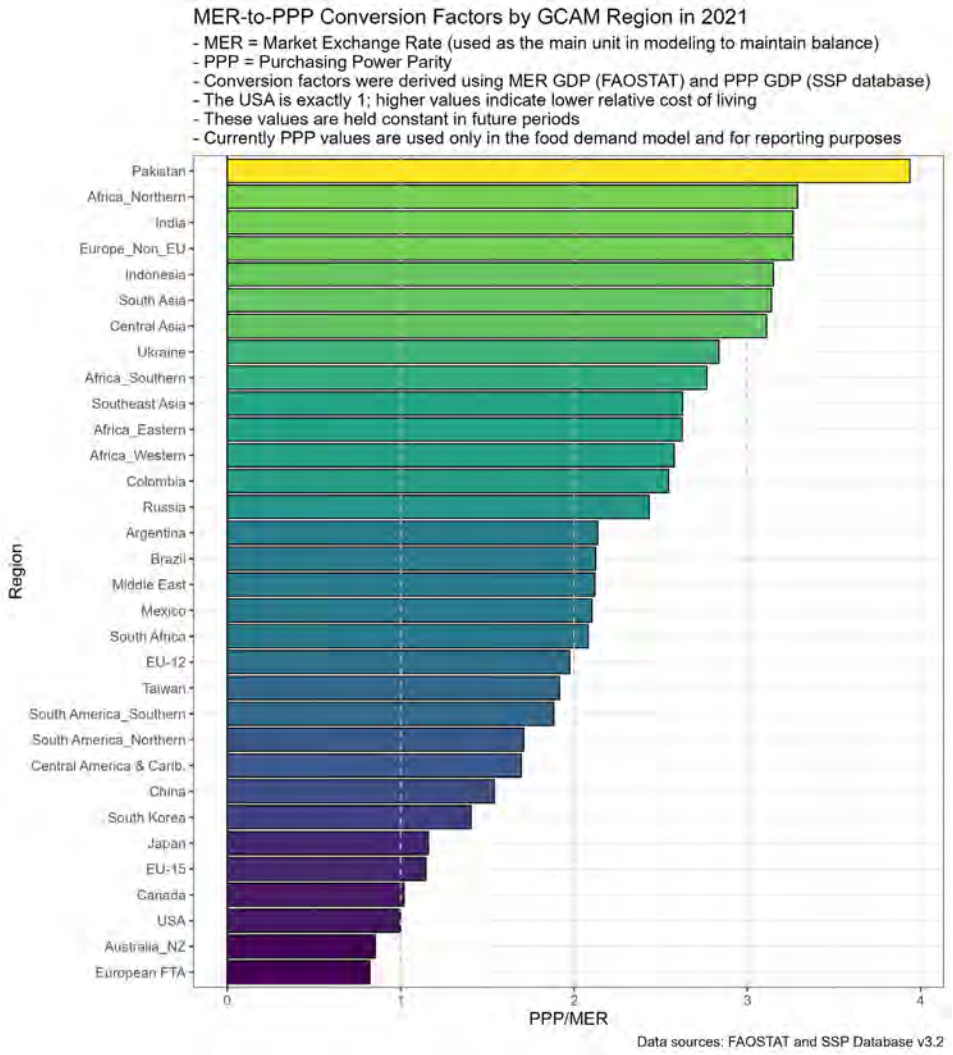


Fig. 7 MER-to-PPP conversion factors in the base year (2021). The MER-to-PPP conversion factors are derived from two data sources: MER GDP (from FAOSTAT/UN) and PPP GDP (from the SSP database). After harmonizing dollar years to the GCAM base year (2021), a small discrepancy remains for the USA, where MER and PPP are not exactly equal. This issue also appeared in previous versions (e.g., ~0.95 in the current Master/GCAM 8.3). Note that only GDP growth rates from the SSP database are used to extend historical observations, so it has not been necessary to reconcile the SSP database exactly with historical observations. However, we expect the PPP-to-MER conversion factor to be 1 for the USA. The value was ~0.98 with the updates in this CMP and we rescaled regional values to ensure USA is 1.

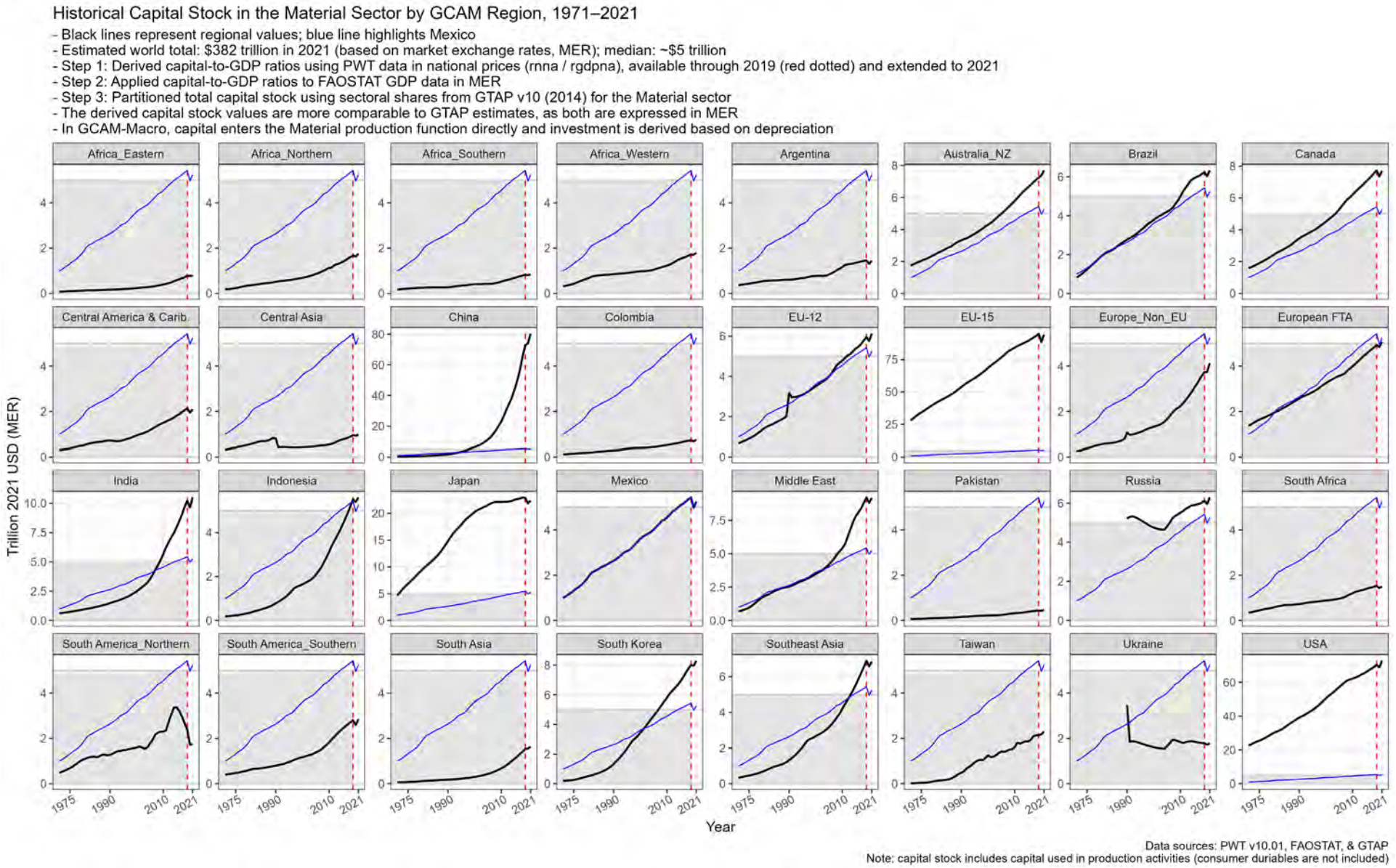


Fig. 8 Historical Capital Stock in the Material Sector by GCAM region, 1971 – 2021

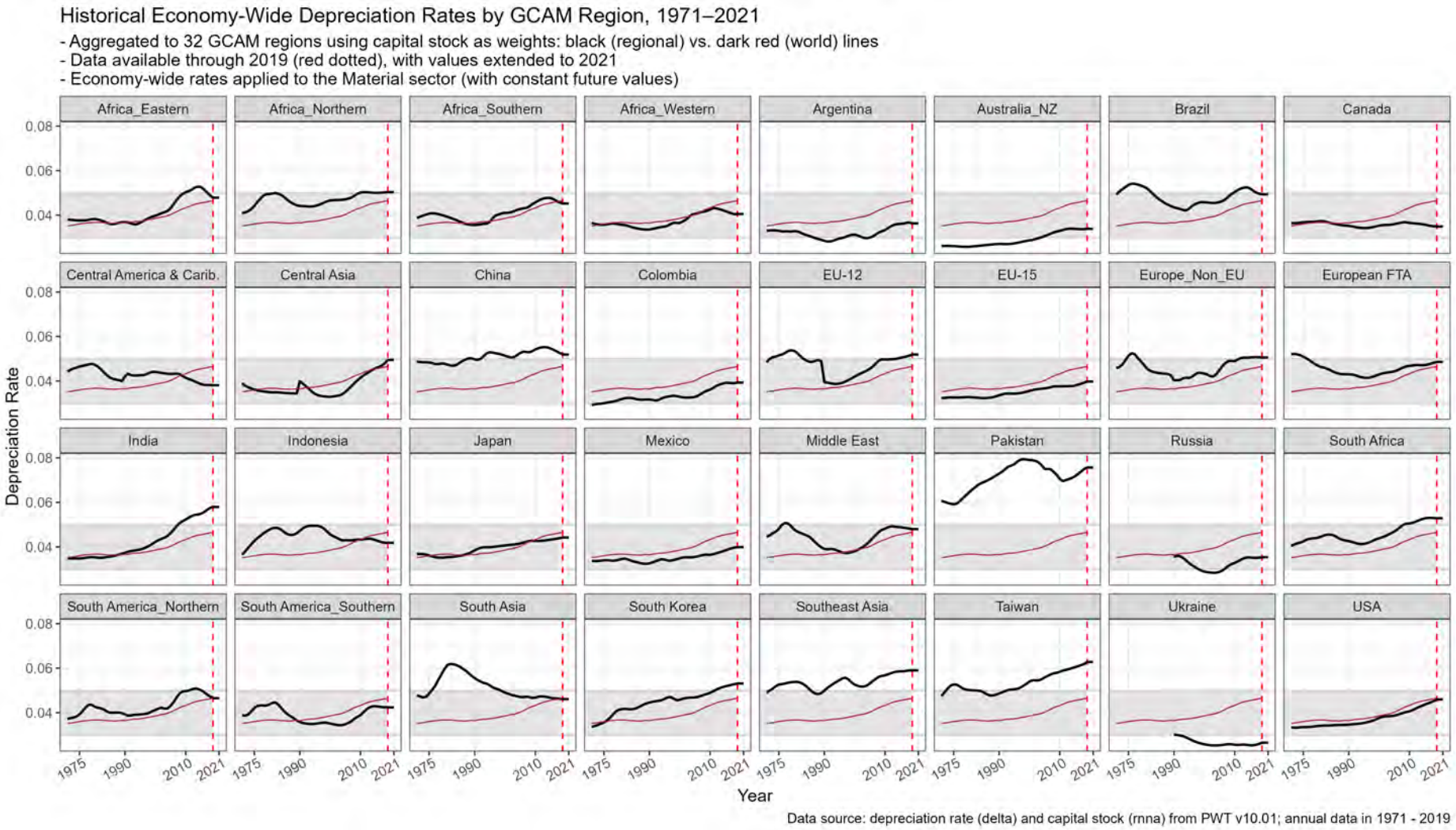


Fig. 9 Historical Economy-Wide Depreciation Rates, 1971 – 2021. Depreciation rates represent the average decline of capital stock (e.g., due to wear and tear). Country-level estimates from PWT were aggregated to GCAM regions using capital-stock-weighted averages. In GCAM's energy and material production modeling, depreciation of capital in detailed energy sectors is not explicitly tracked, as the focus is on new investment (cleared with savings). However, for the Material sector, deriving new investment requires knowledge of capital stock differences across periods and the associated depreciation. This is the context in which the GCAM regional depreciation rates shown here are applied.

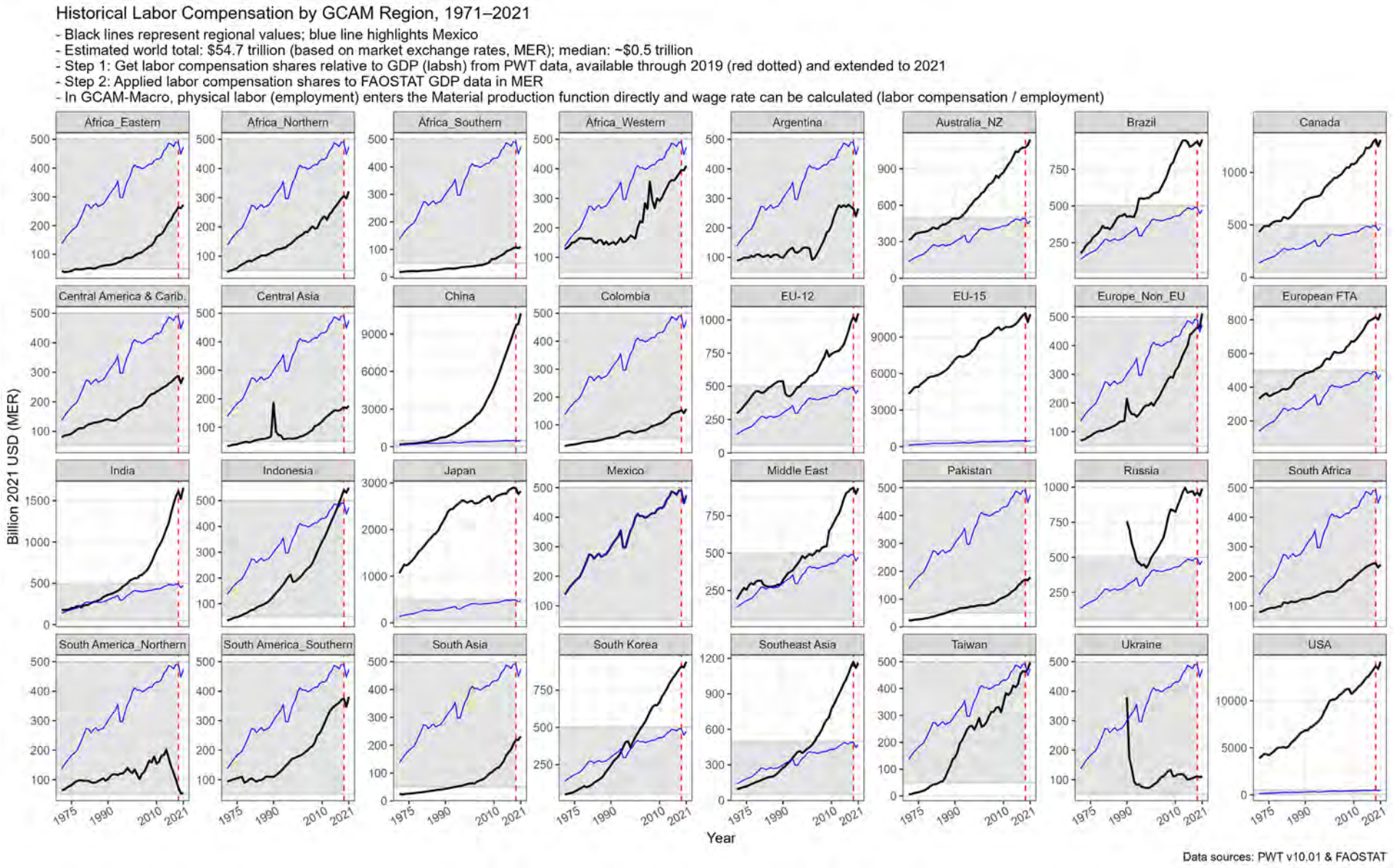


Fig. 10 Historical Labor Compensation by GCAM Region, 1971 – 2021

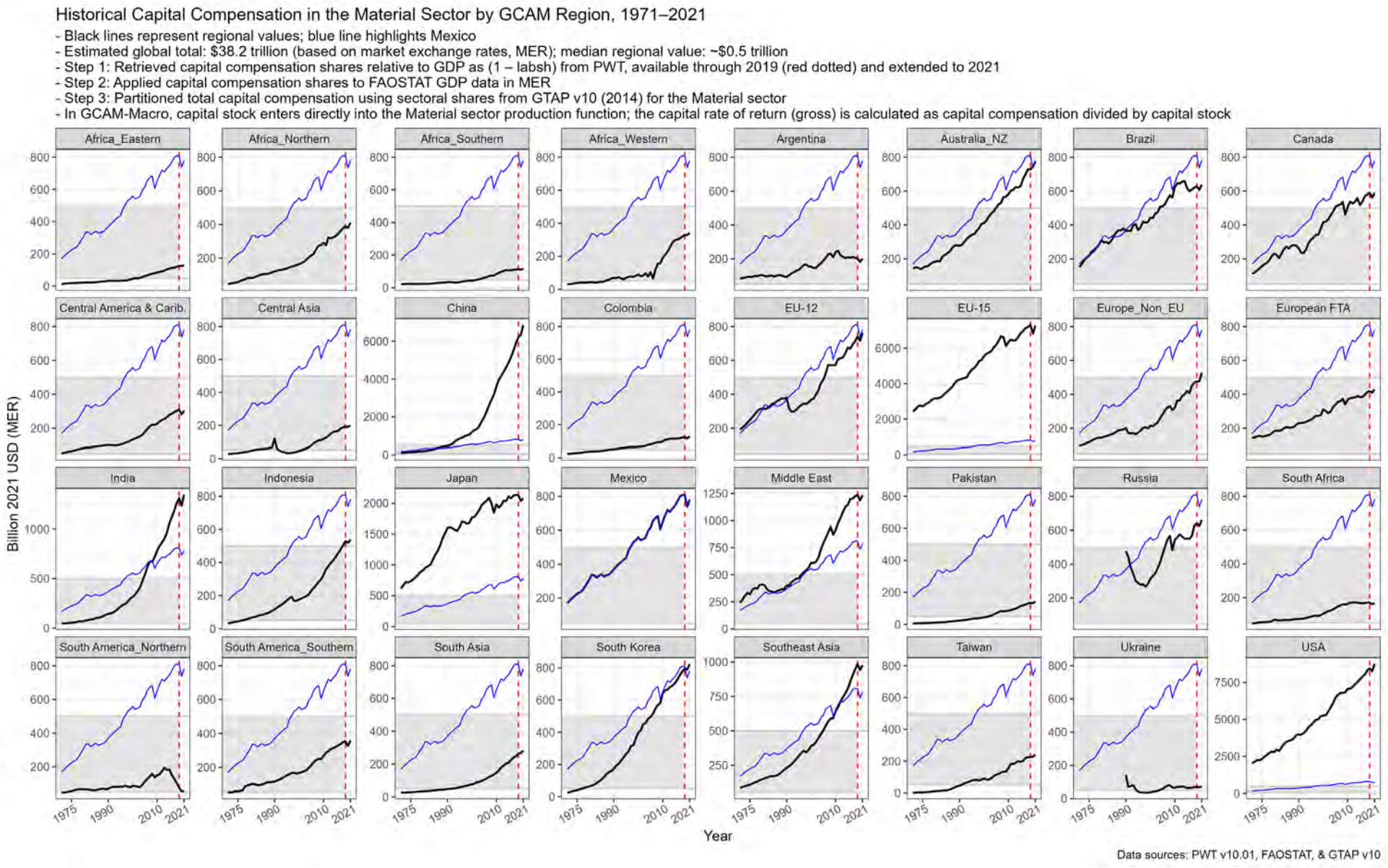


Fig. 11 Historical Capital Compensation by GCAM Region, 1971 – 2021

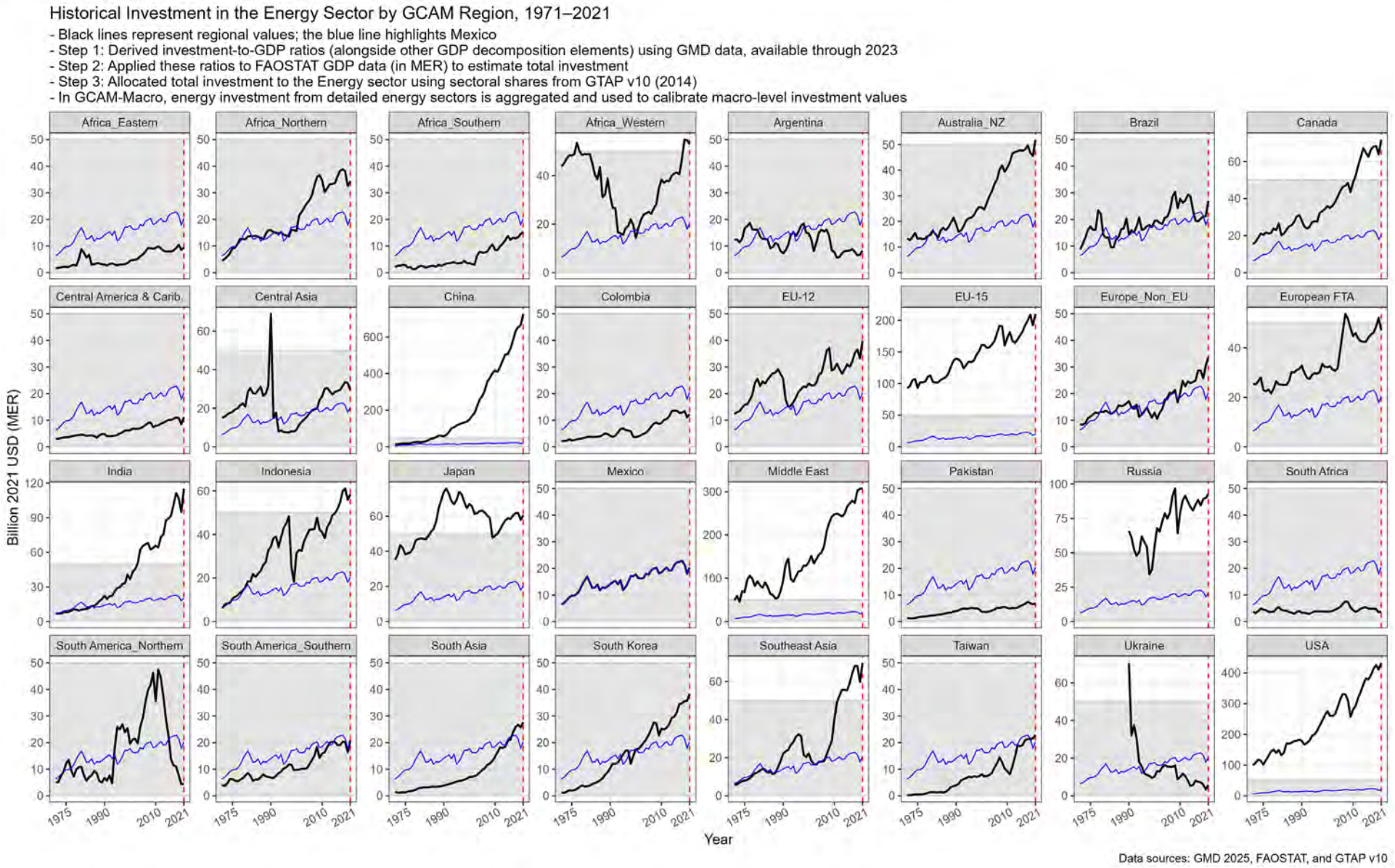


Fig. 12 Historical Investment in the Energy Sectors by GCAM Region, 1971 – 2021

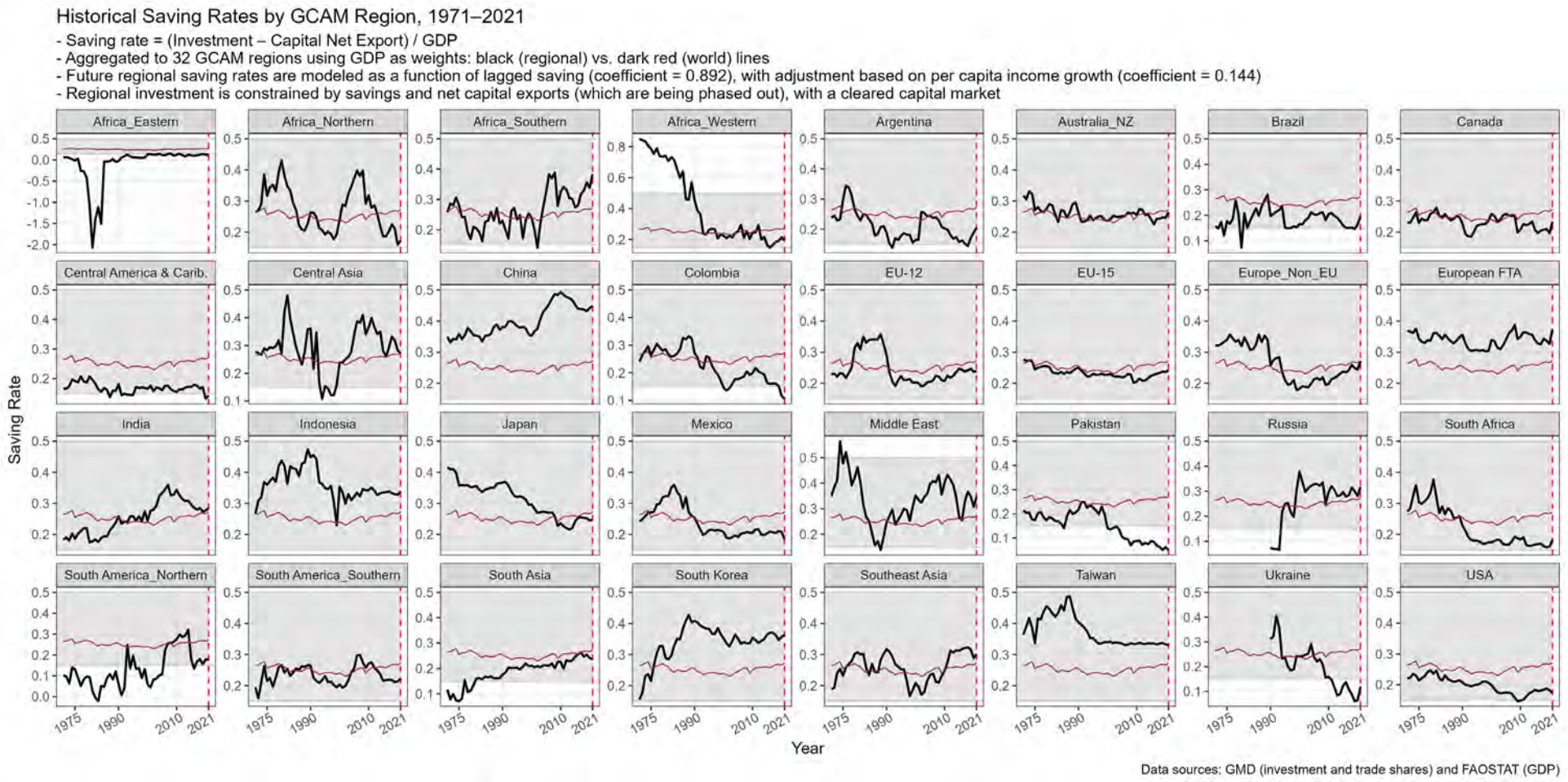


Fig. 13 Historical Saving Rates by GCAM Region, 1971 – 2021. Saving rates are defined as (GDP-consumption)/GDP, which is equivalent to (investment + net exports)/GDP, where net exports are treated as negative capital net exports in our processing. Thus, Country-level saving rates were aggregated to GCAM regions using GDP as weights. For future projections, saving rate parameters follow the approach in previously GCAM version (v7 -v8.3), where a pooled regression model was estimated with panel data (GCAM regions × PWT data in 5-year steps). The parameters indicate lower saving rates with higher income growth. Those estimated parameters are used directly here for simplicity and consistency, though they carry uncertainty due to model specification and data coverage; future work may refine them with region-specific estimates.

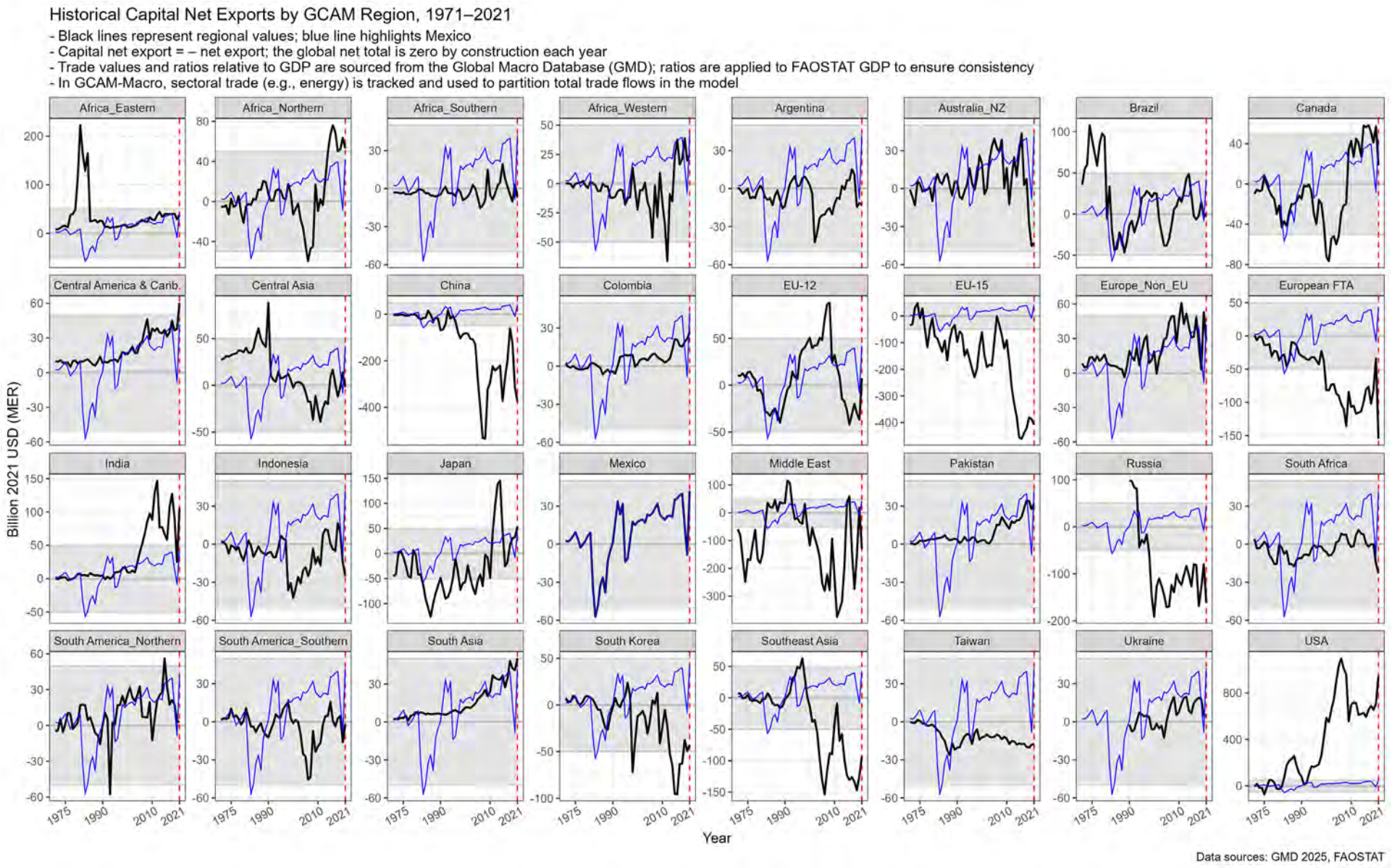


Fig. 14 Historical Capital Net Exports by GCAM Region, 1971 – 2021

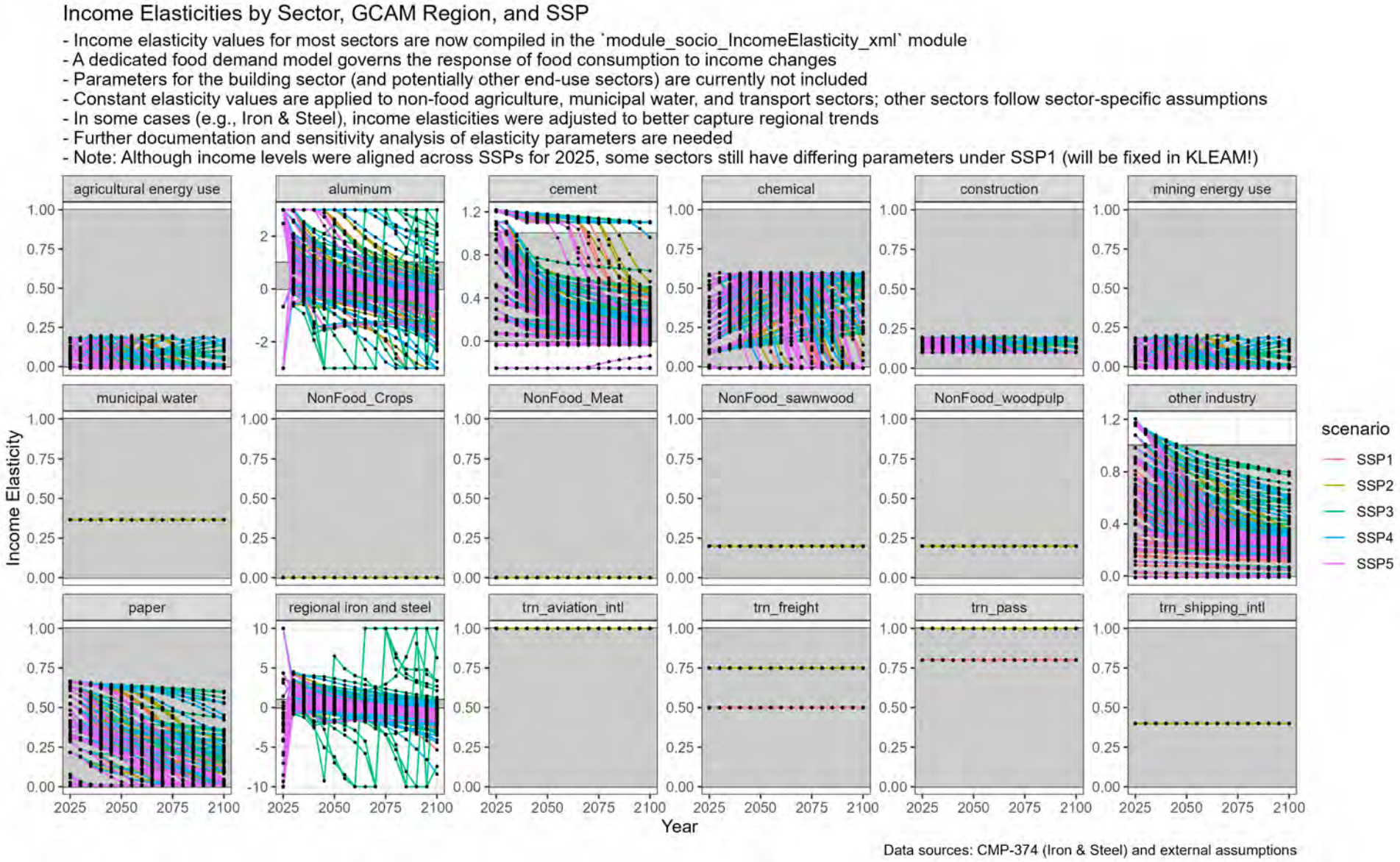


Fig. 15 Income Elasticities by GCAM Sector, Region, and SSP

4. GCAM validation runs

In accordance with the GCAM CMP convention, we present GCAM projection results, comparing the Updated branch with a recent Master branch (GCAM v8.3) for reference, RCP 2.6-fixed and RCP 2.6-open scenarios across shared socioeconomic pathways (GCAM core & SSP1-5 assumptions; excluding SSP2/3/4-RCP2p6). There are 24 SPA (shared policy assumption) and macroeconomic (fixed vs. open) scenarios in total (**Fig. 16**), as RCP 2.6 was not solved in SSP2-SSP4. The current master corresponds to GCAM v8.3. CI352 and CI365 are the pull request folders storing the validation runs.

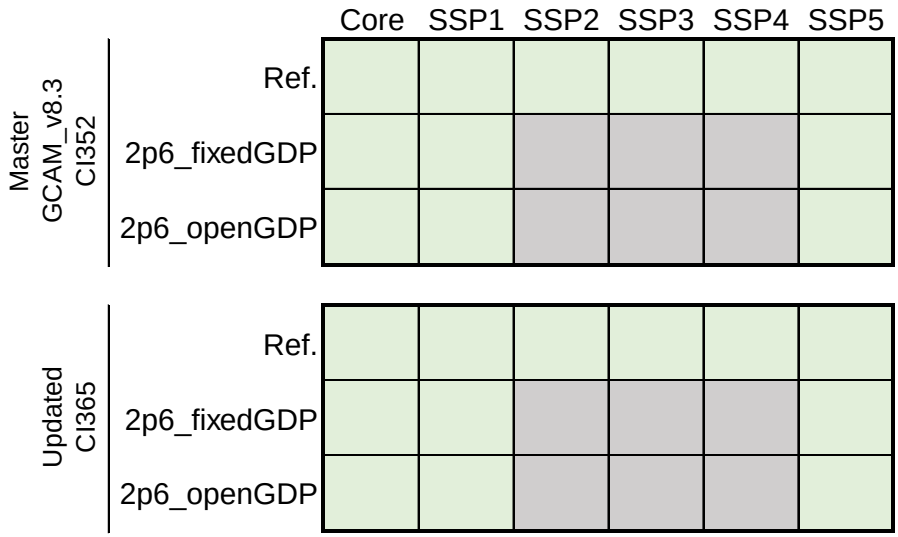
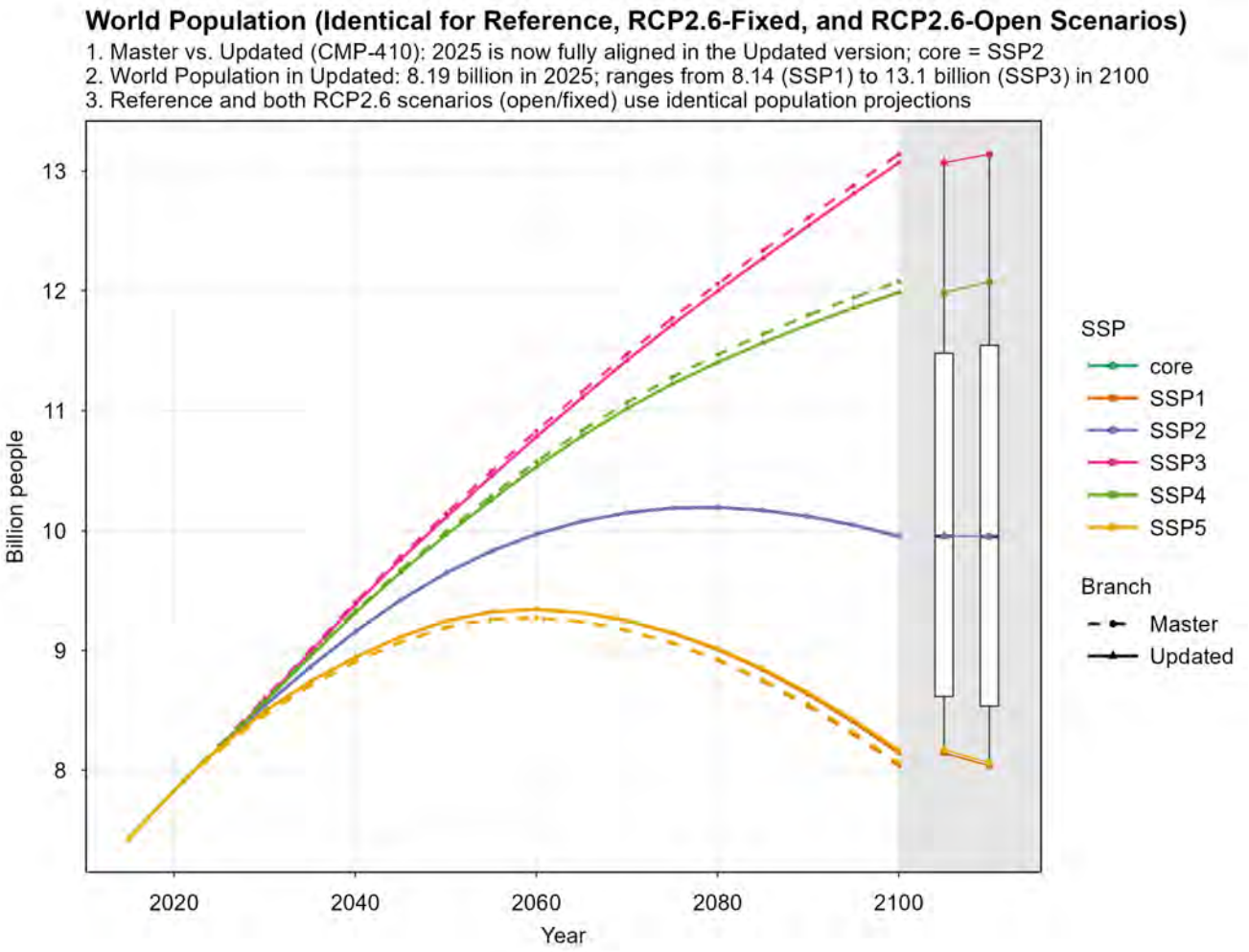


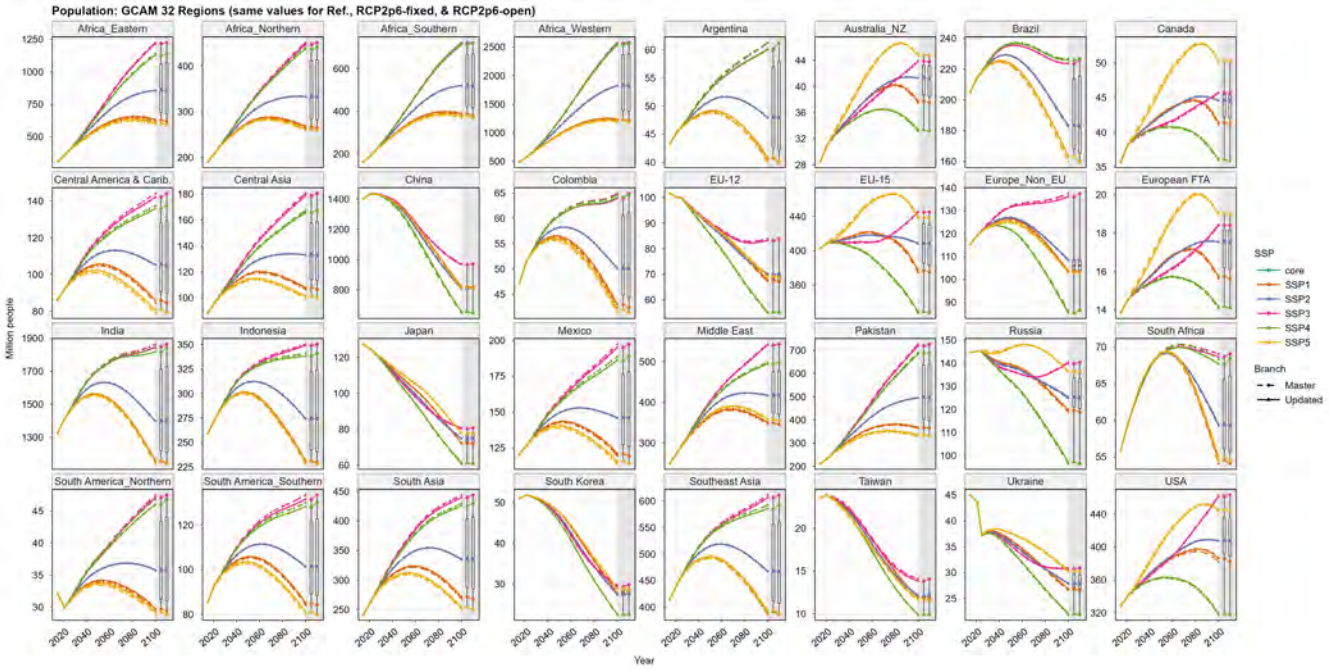
Fig. 16 GCAM validation scenarios

We update the key validation figures (in line with CMP-399), now highlighting revised results for national account variables—only key indicators are indexed here. Detailed sectoral results for energy, agriculture, and land use are not included in this document, as their impacts were relatively minor; they are available on internal Confluence pages. The figures are designed to be self-explanatory, with explanatory notes included in the captions where applicable.

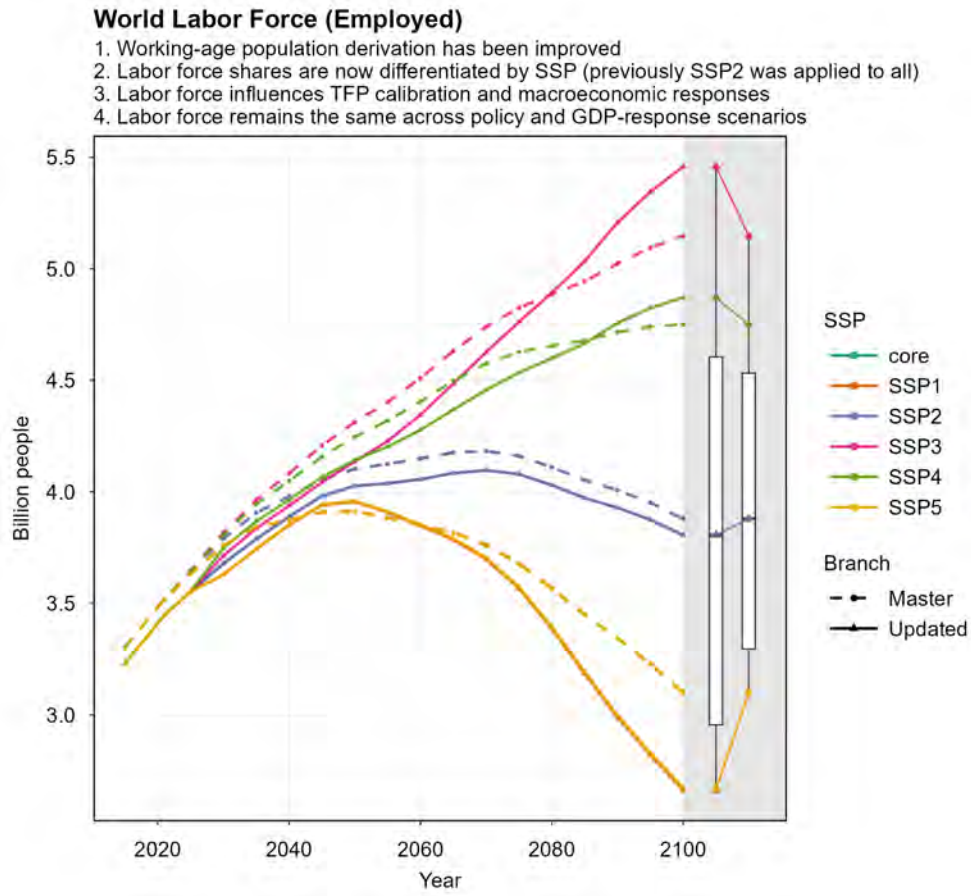
4.1. Population and employment



World population across SPA scenarios. The lines present population projections by 2100 by scenario (SSPs or GCAM core; GCAM-core is identical to SSP2 for population) across branches, Master (dotted lines) vs. Updated (solid lines). The boxplots show distributions of 2100 values across branches Master (left) vs. Updated (right), i.e., including the median values (line), the 1st and 3rd quartiles (boxes), and the 0-100 percentile ranges (whiskers) of the scenarios. Data of the boxplots are shown (points) and the lines connecting these points across branches show changes due to the updates. The same boxplot format (2100 scenario distribution, where applicable) is applied consistently across all validation figures.

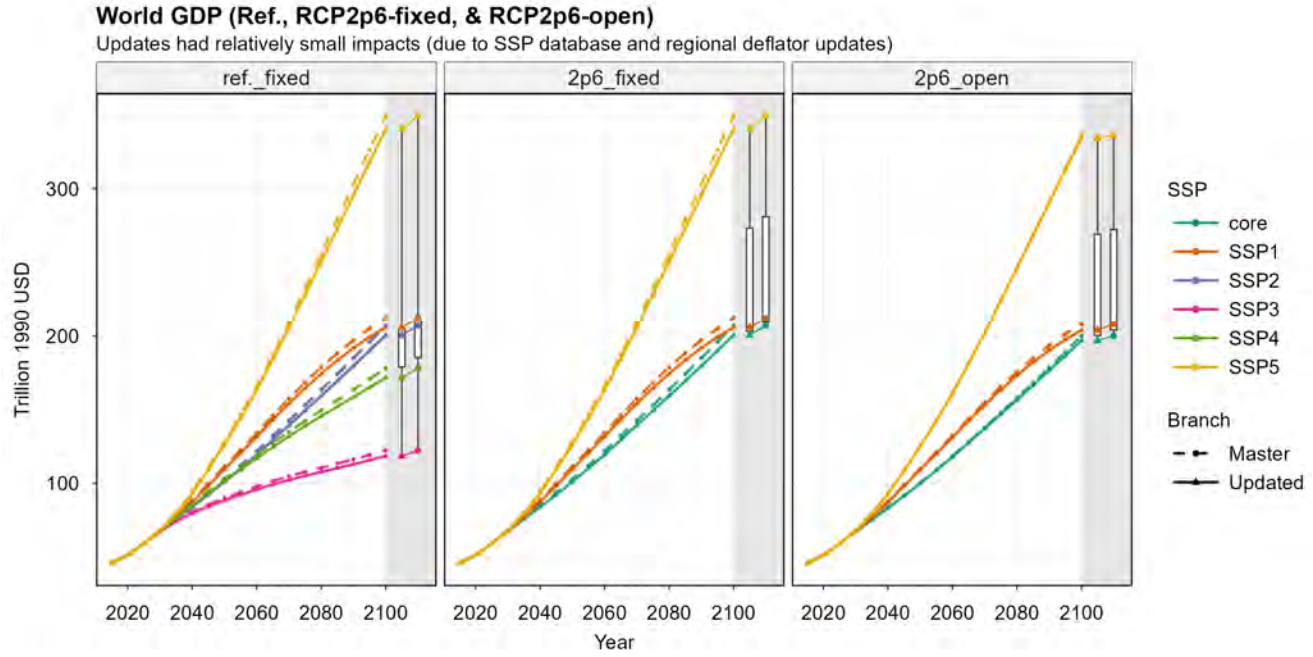


Regional population projections across SPA scenarios.

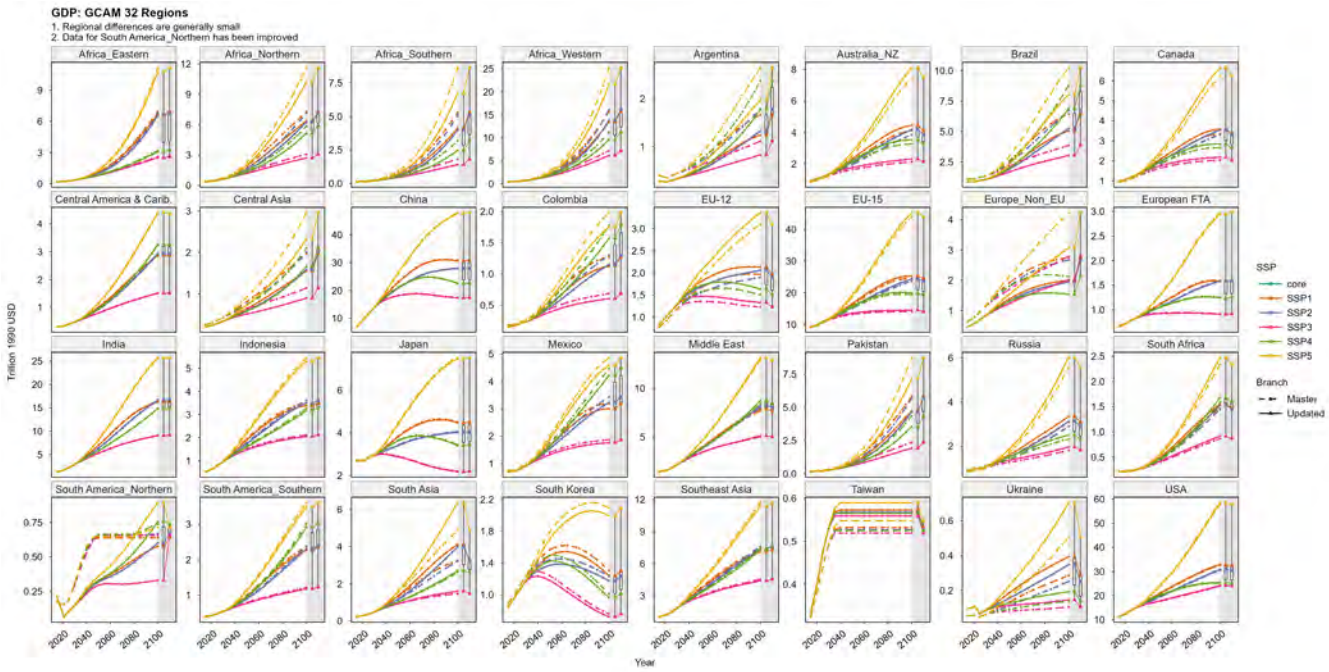


World labor force (employment) projections across SPA scenarios.

4.2. GDP

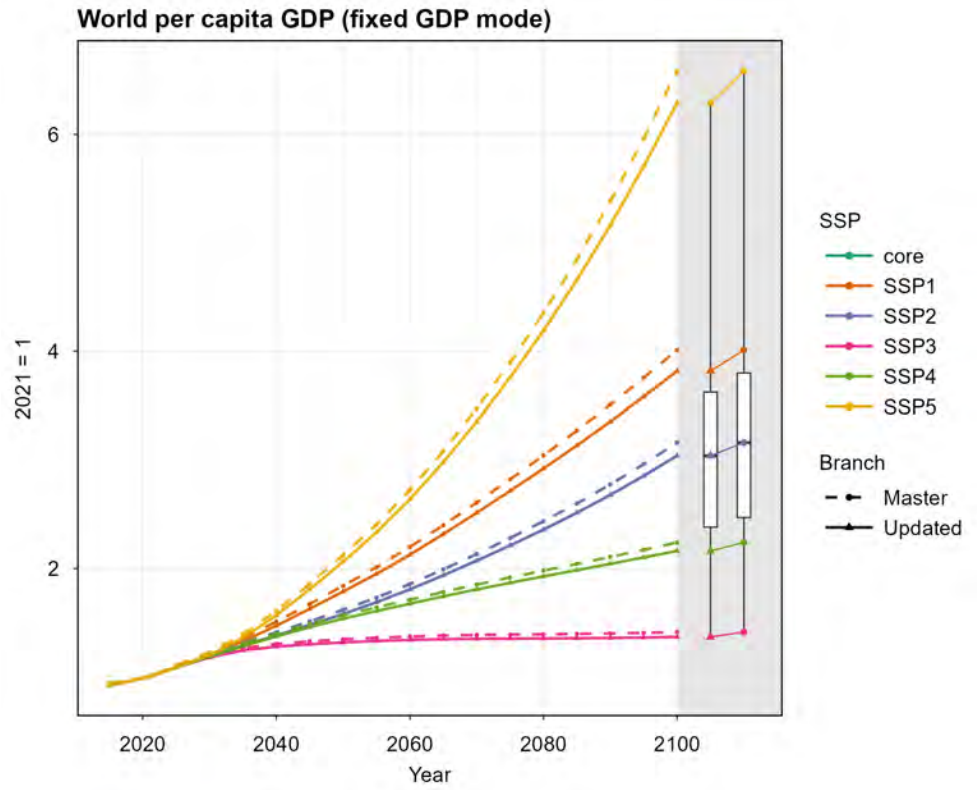


World GDP across SPA and GDP-response (fixed vs. open) scenarios

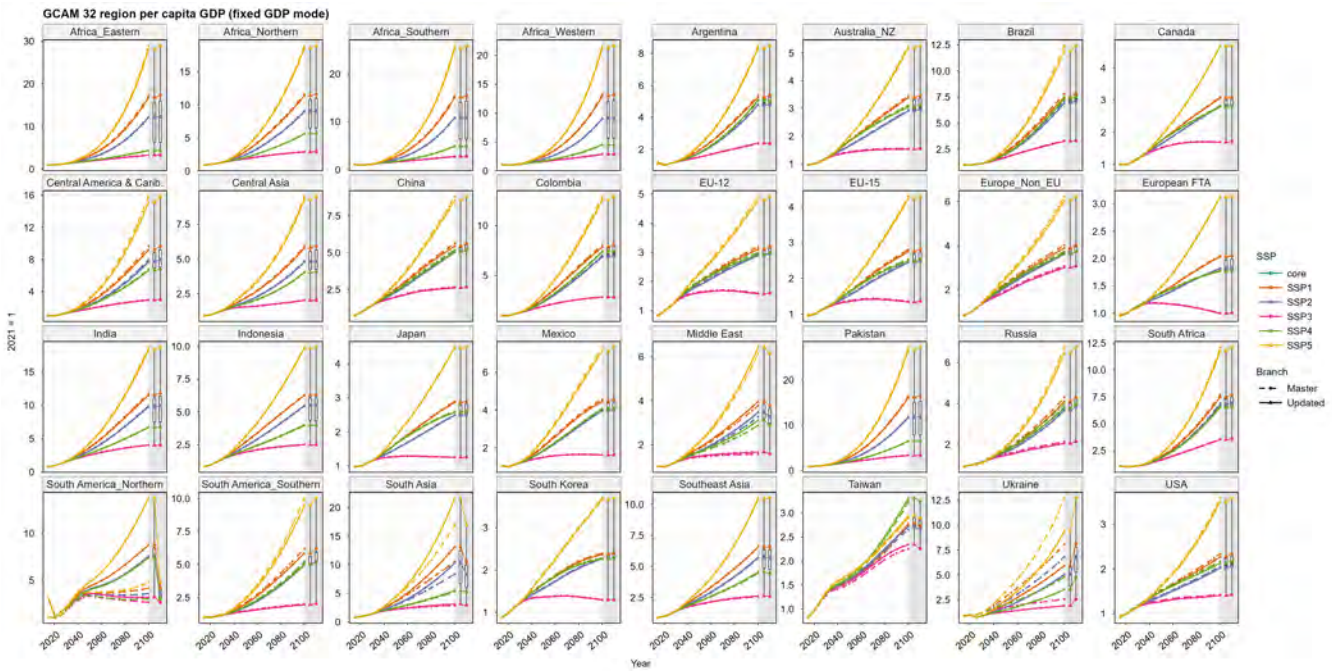


Regional GDP projections across SPA scenarios.

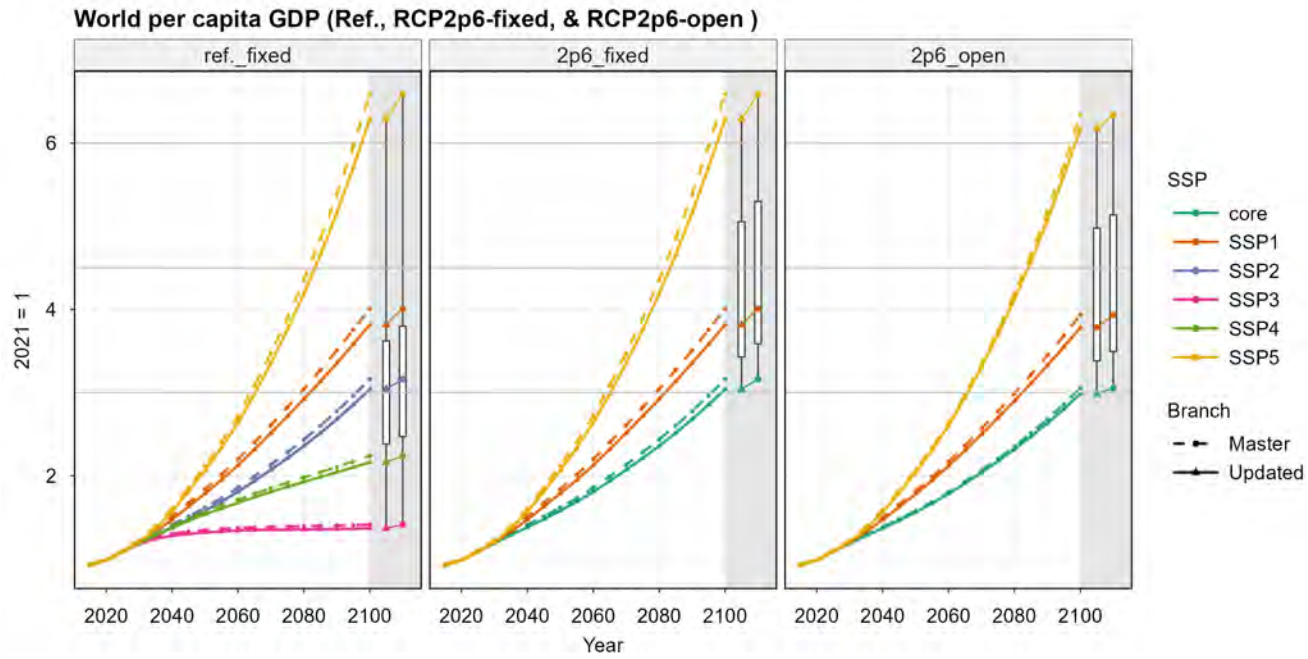
4.3. Per capita GDP and total factor productivity (TFP)



World per capita GDP across SPA (fixed-GDP mode) scenarios, relative to 2021



Regional per capita GDP across SPA (fixed-GDP mode) scenarios, relative to 2021



World per capita GDP across SPA and GDP-response (fixed vs. open) scenarios, relative to 2021

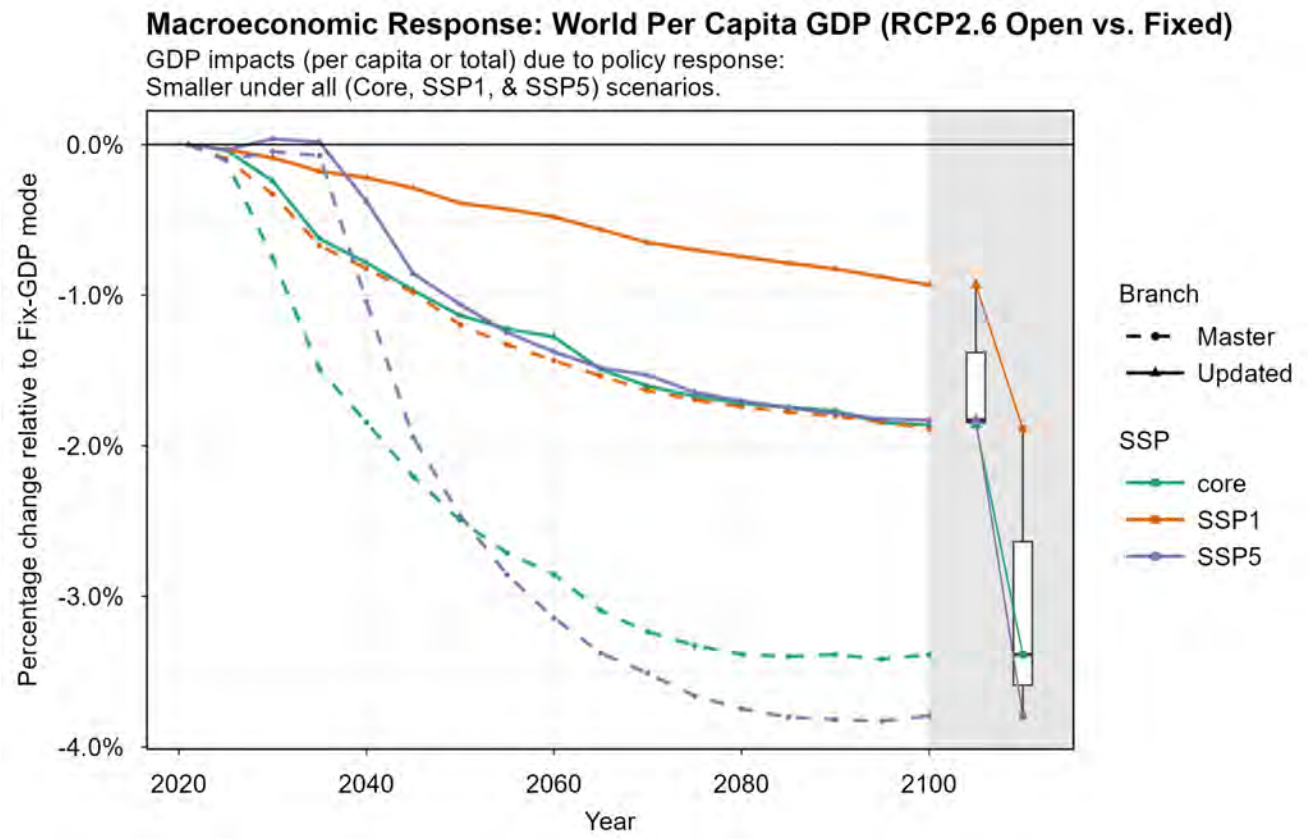
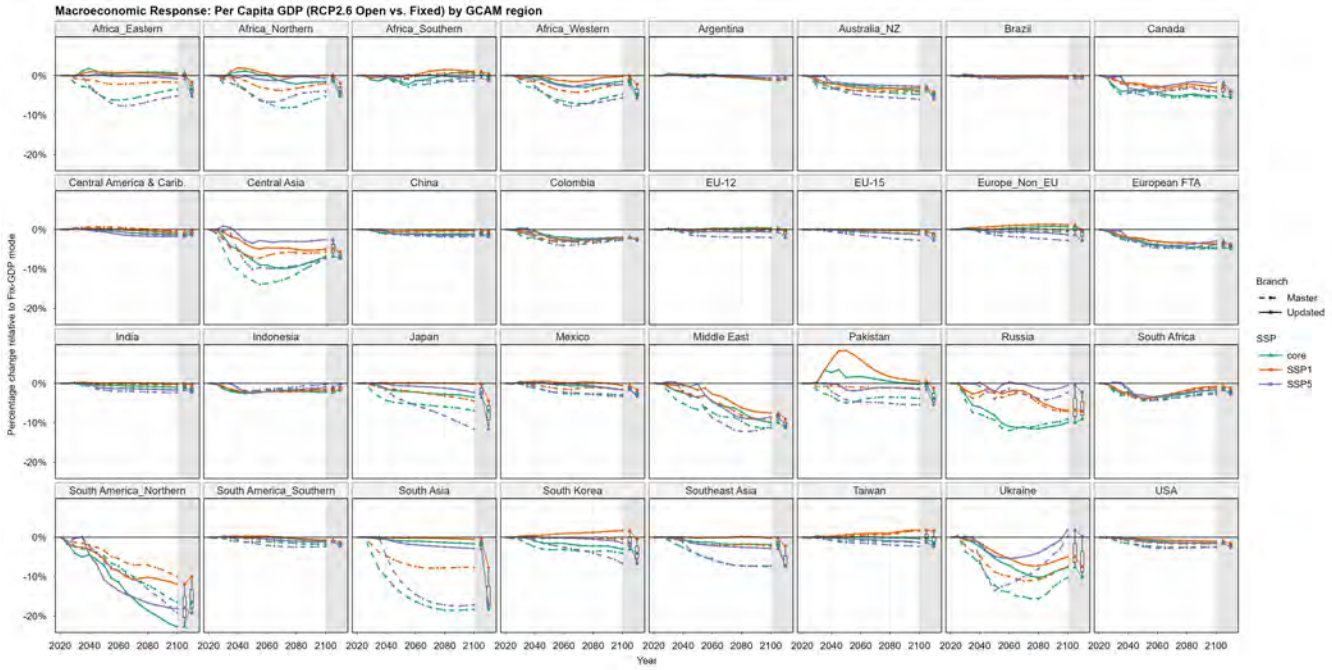
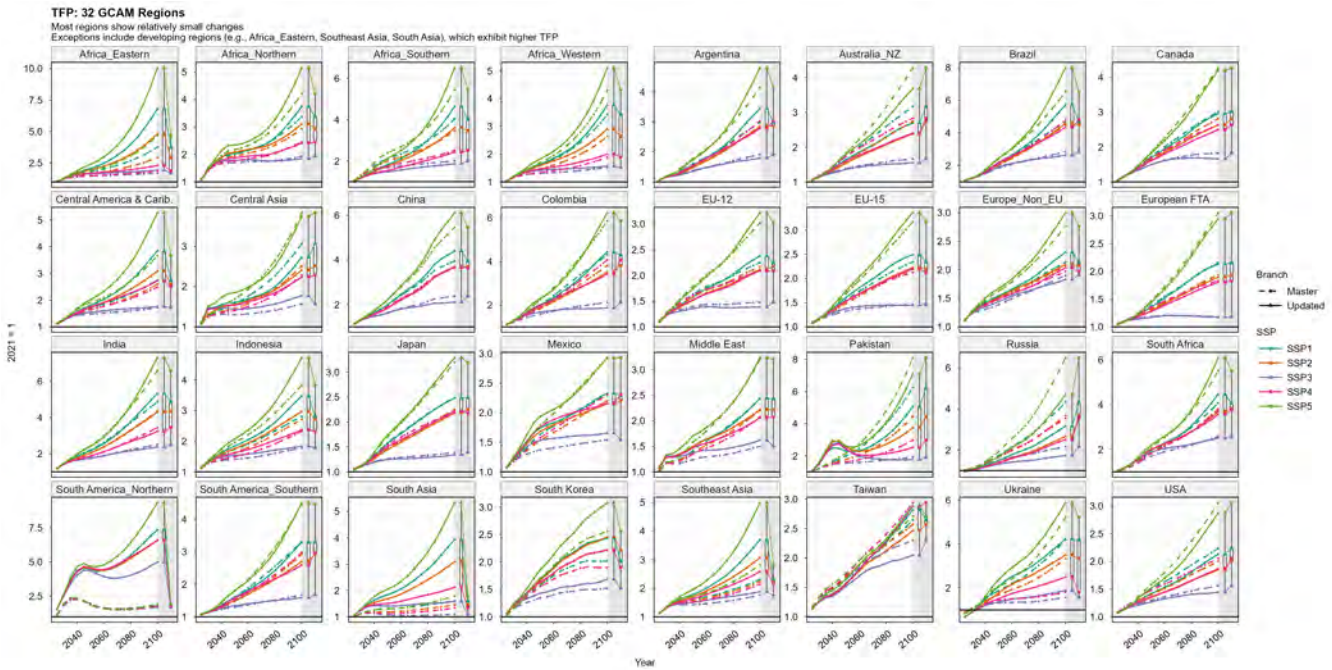


Fig. 17 World per capital GDP impacts due to RCP2p6 policies (open vs. fixed) across SPA



Regional per capital GDP impacts due to RCP2p6 policies (open vs. fixed) across SPA



Calibrated total factor productivity (TFP) by 32 GCAM regions

4.4. Other national account variables

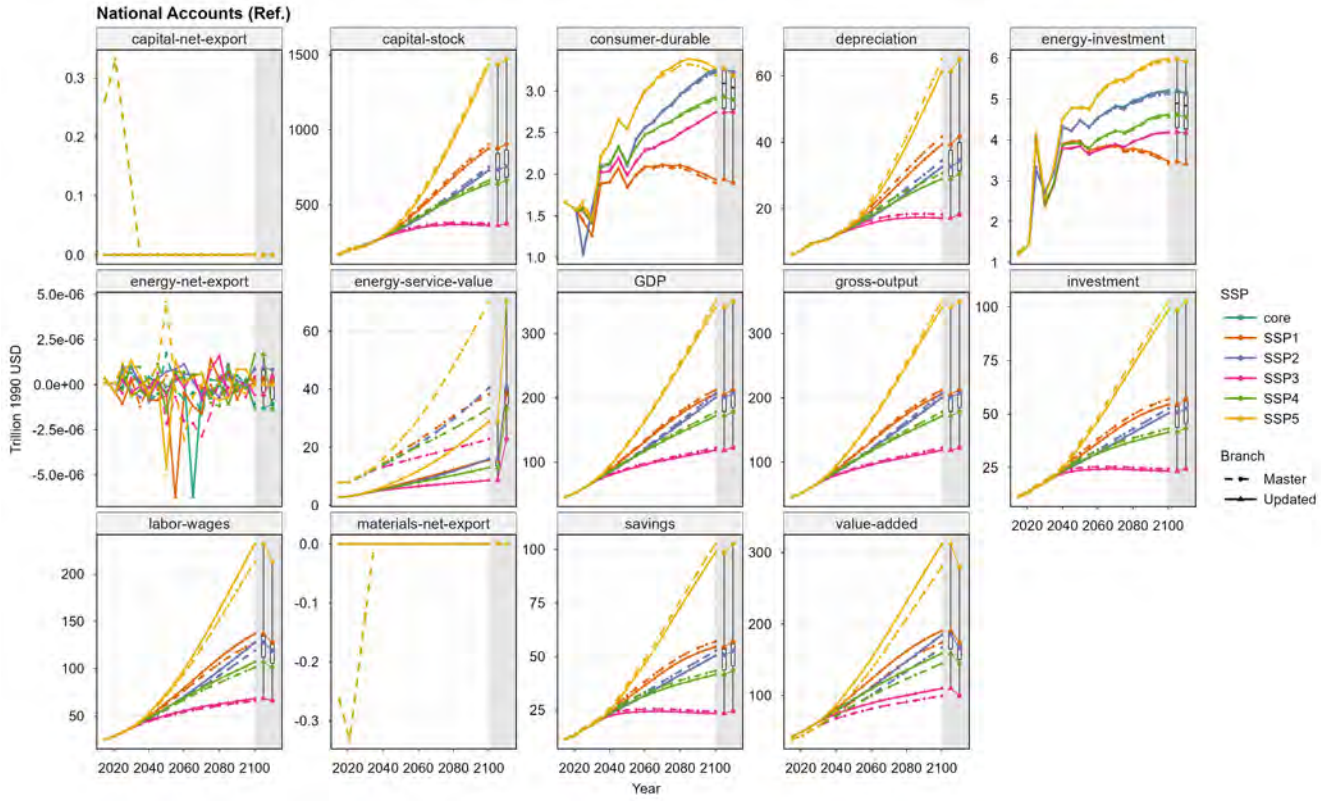
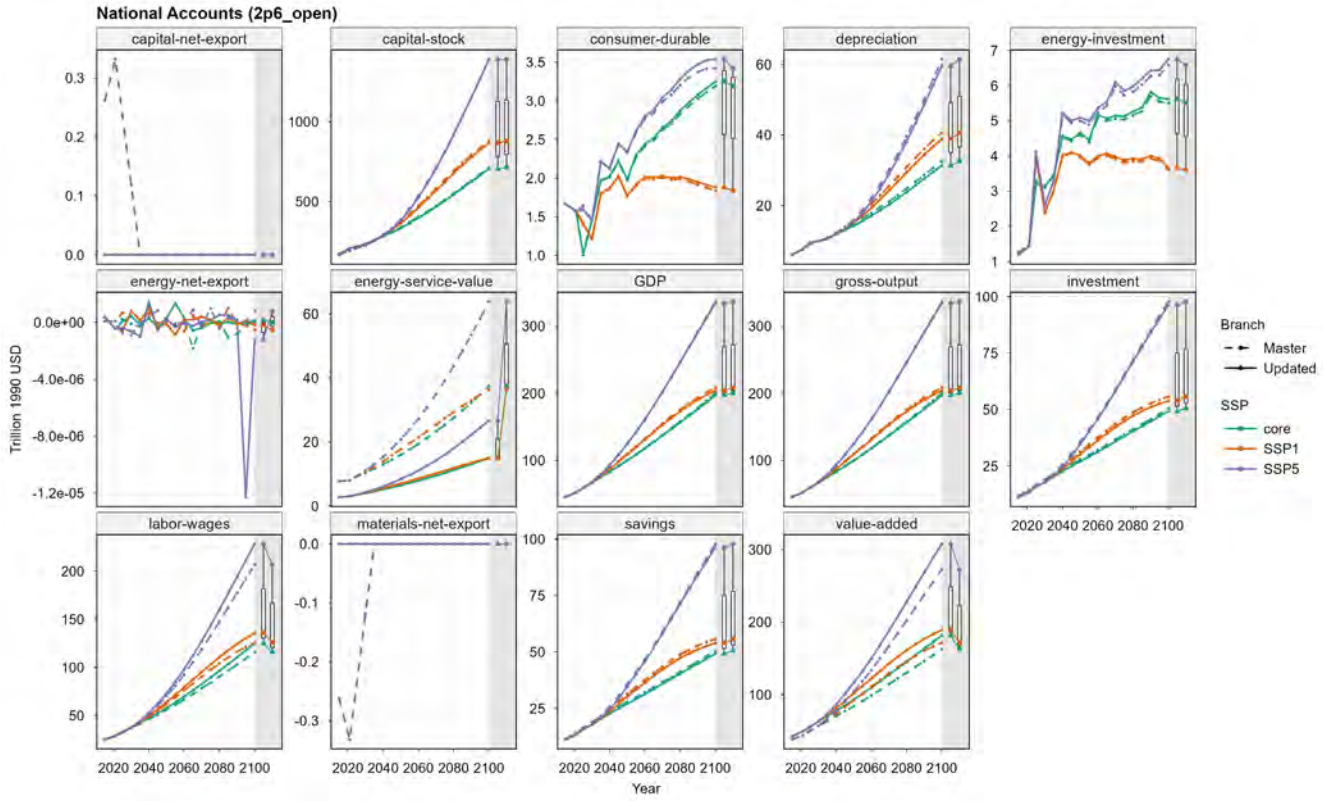
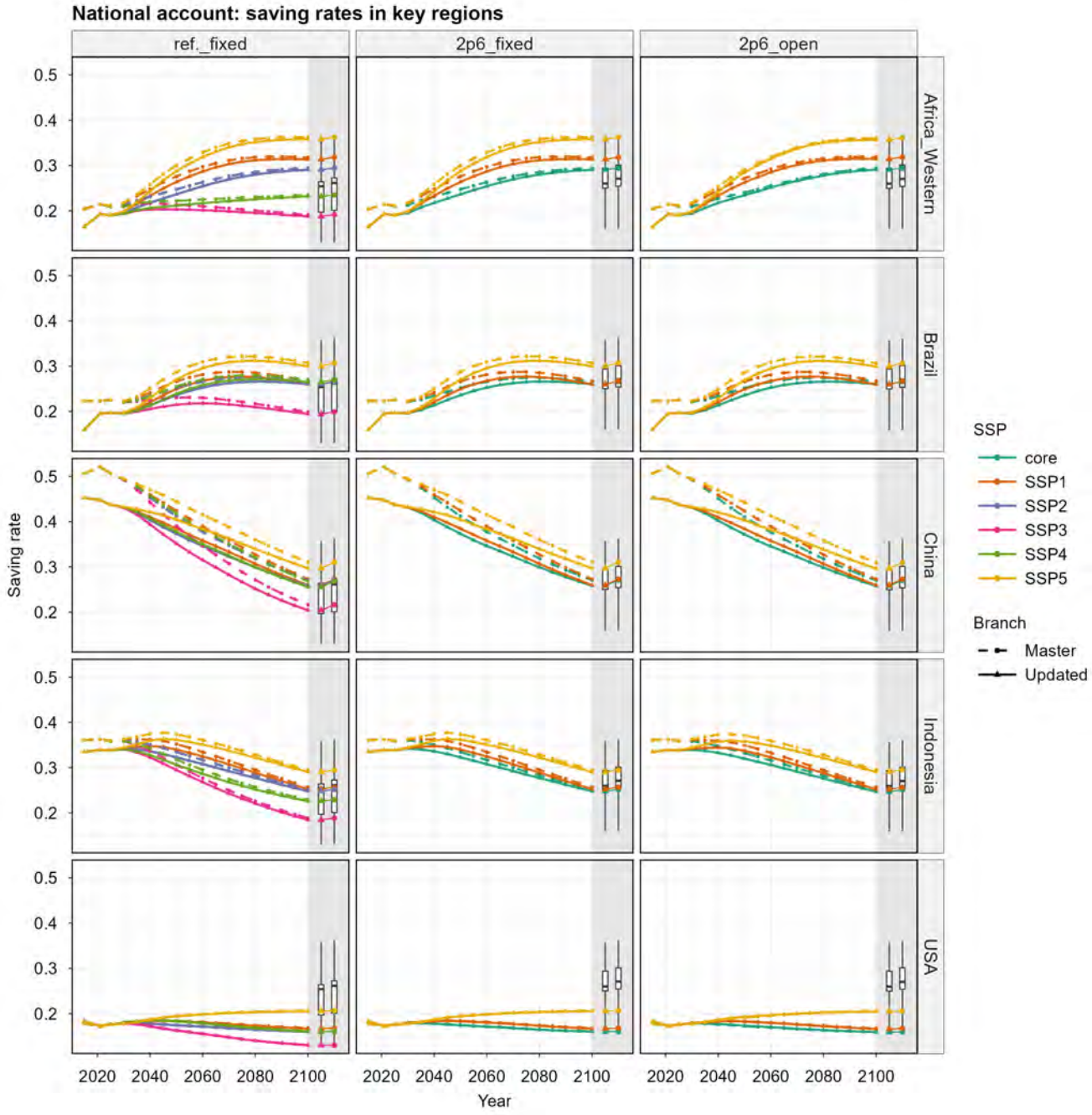


Fig. 18 National account variables in Ref, global.

- Energy service values show relatively larger changes due to updates in labor and capital compensation data.
- Trade imbalances were corrected so that global capital net exports and materials net exports sum to zero.
- Energy net exports are effectively zero, with minor variation due to rounding.
- The reported metrics—including capital stock, value added (labor + capital compensation), labor wages (labor compensation), gross output, and investment—refer to the Materials sector.

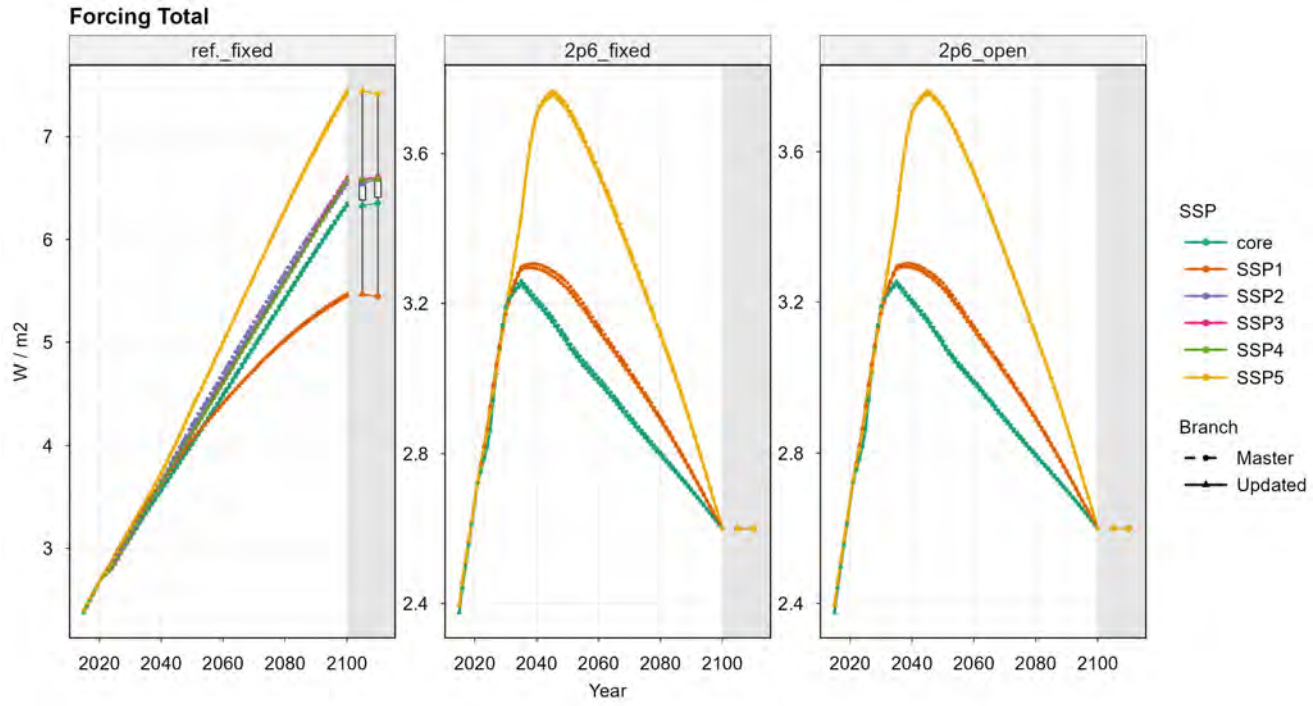


National account variables in rcp2p6 (open), global.

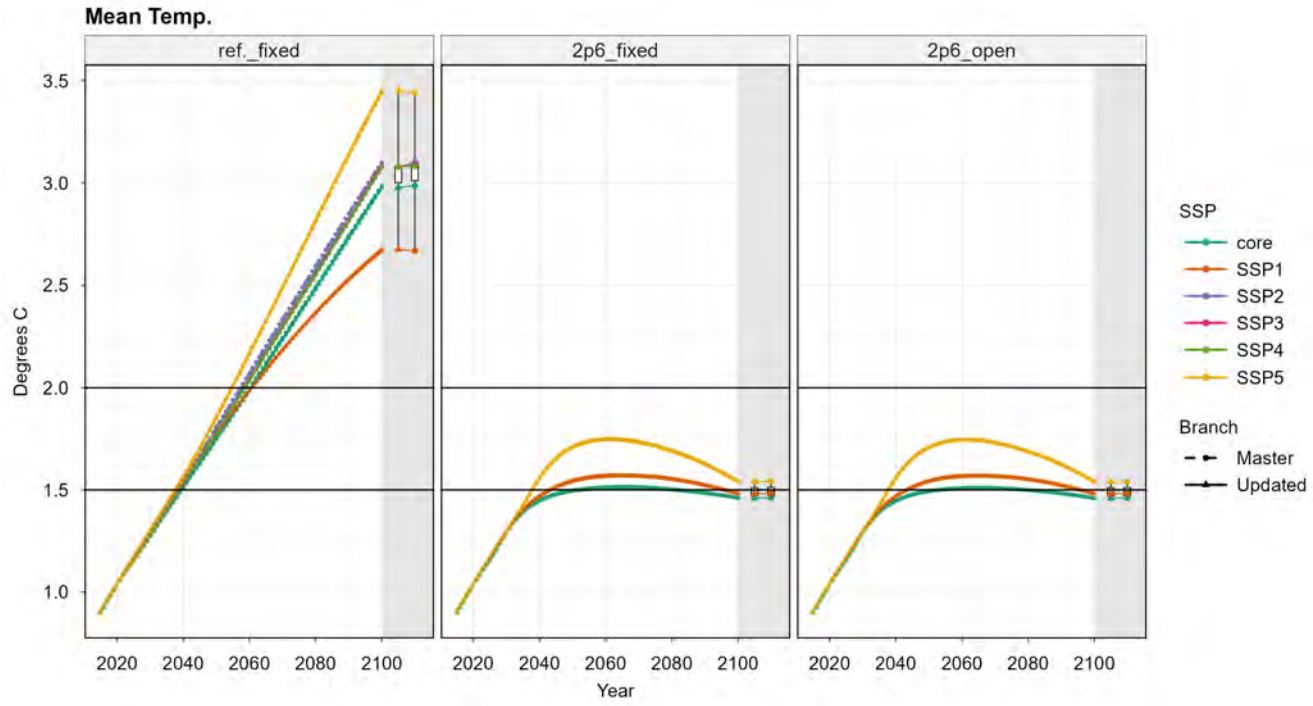


National account: Saving rates

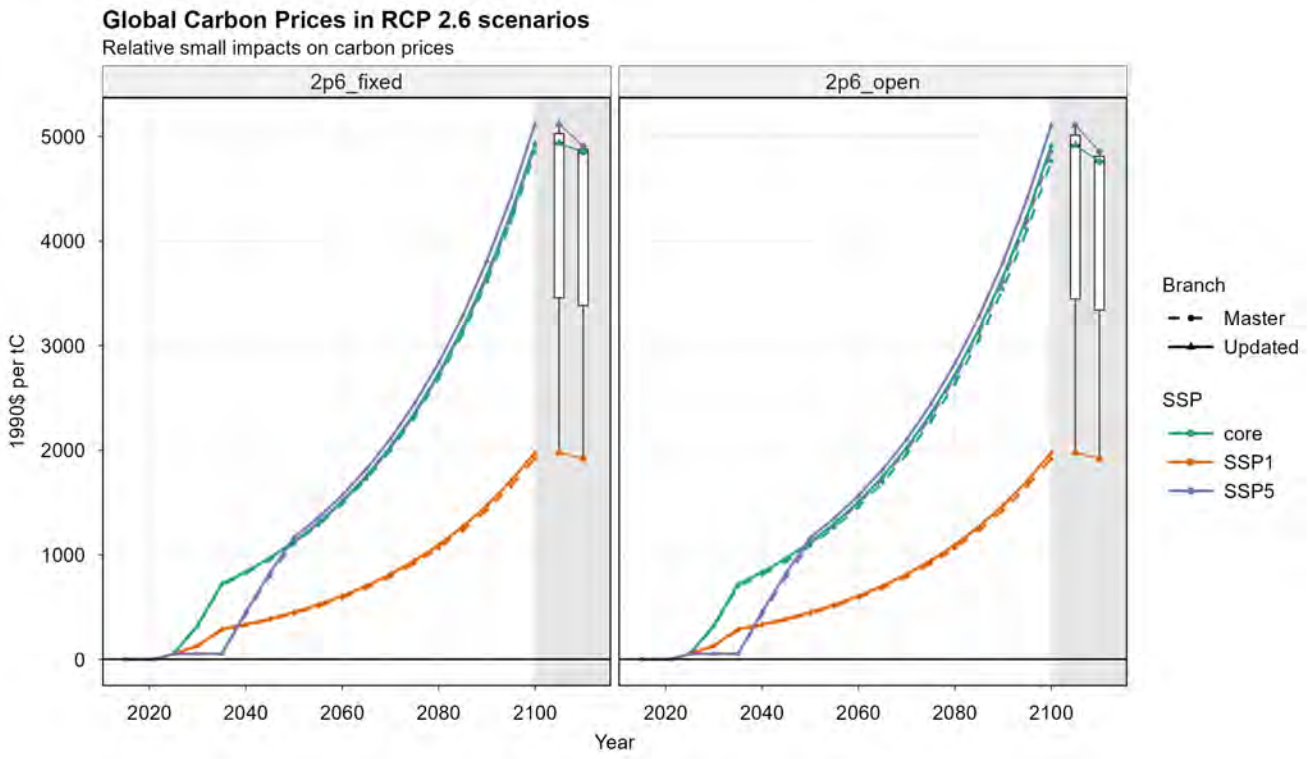
4.5. Radiative Forcing, Temperature, and Carbon Prices



Total forcing across SPA and GDP-response (fixed vs. open) scenarios.

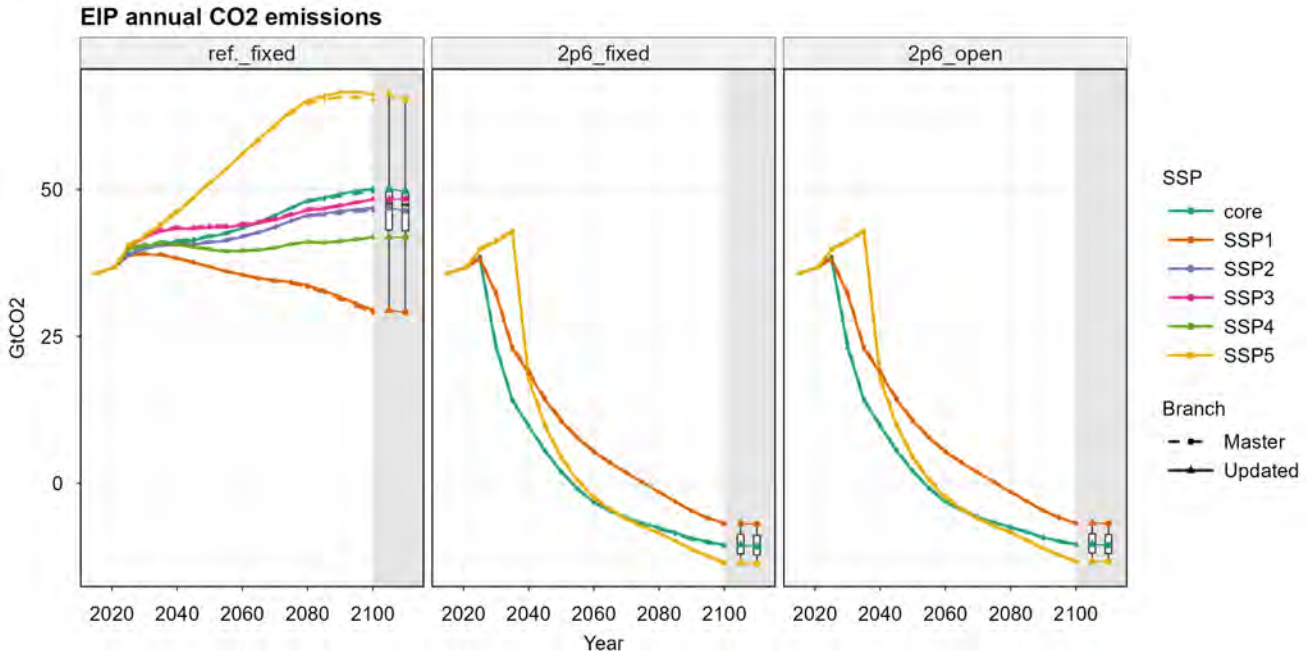


Global mean temperature change across SPA and GDP-response (fixed vs. open) scenarios.

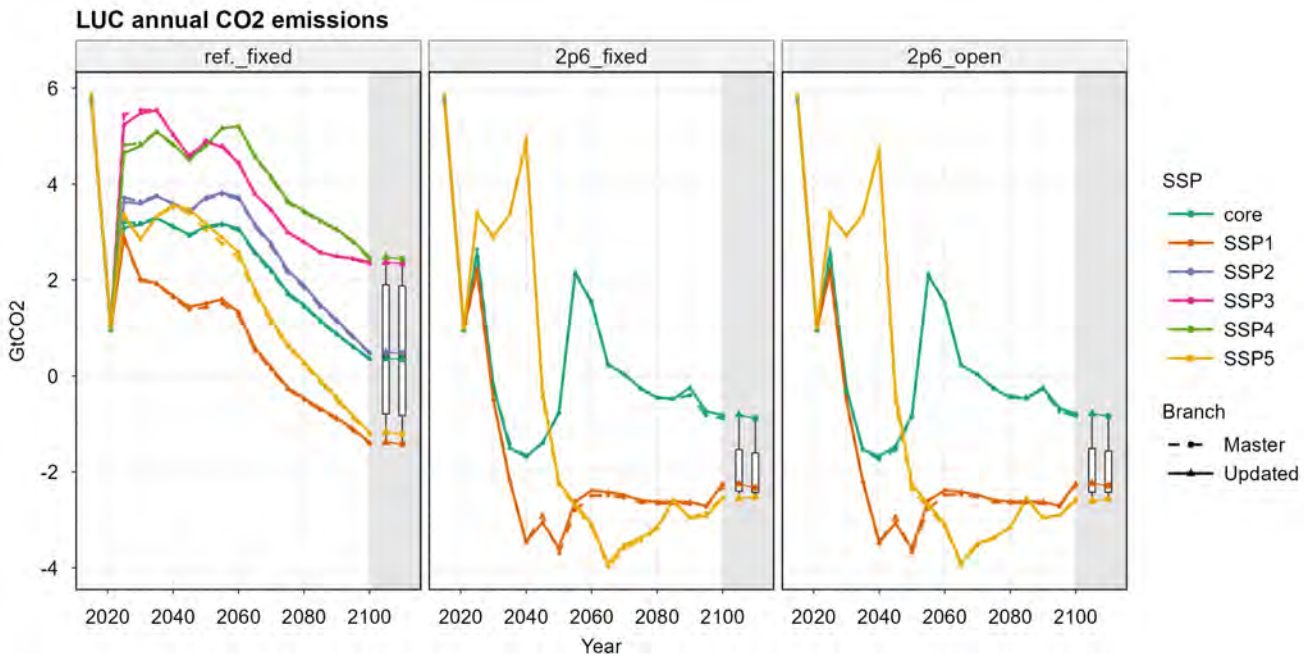


Global carbon prices across SPA and GDP-response (fixed vs. open) scenarios.

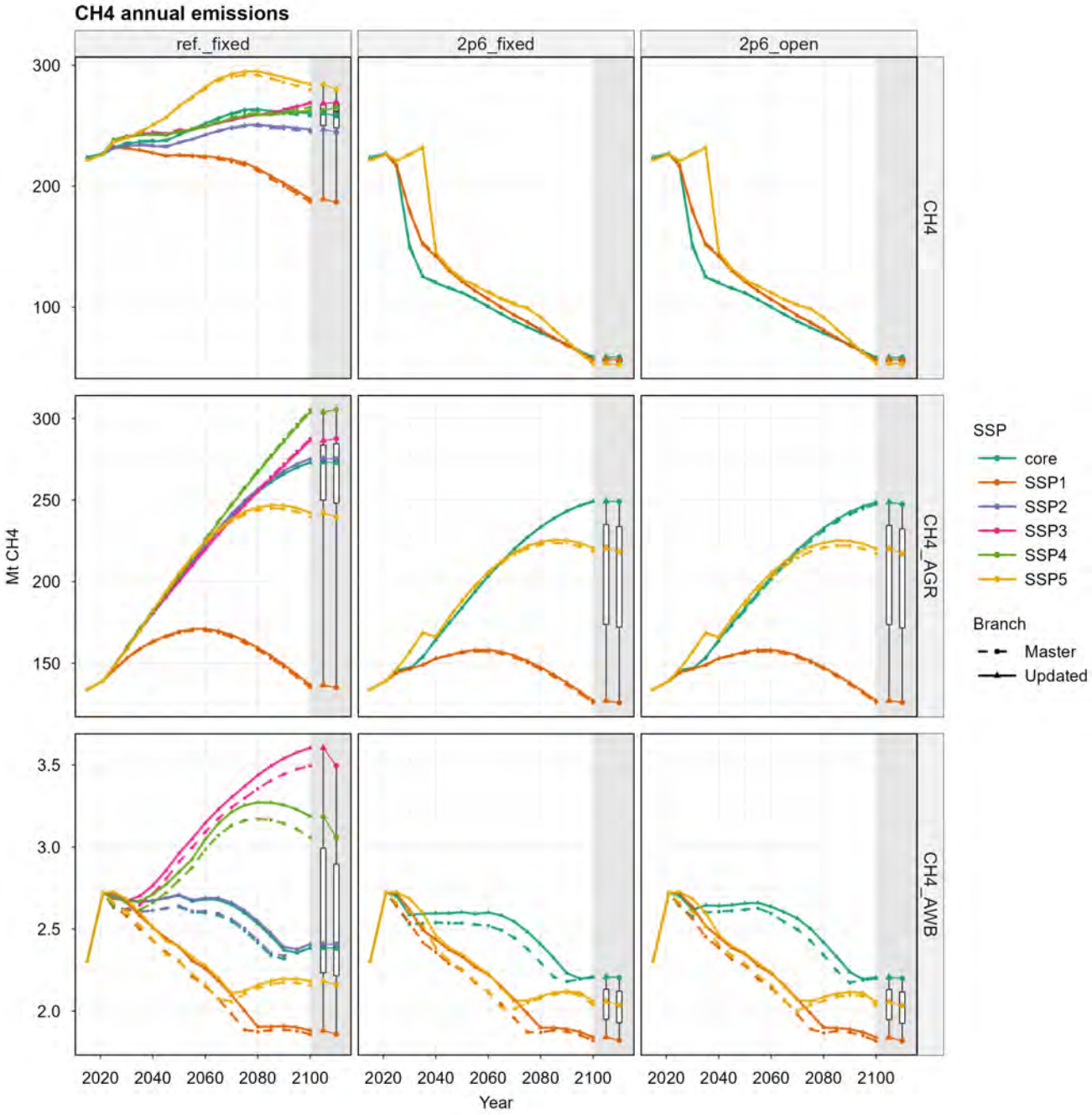
4.6. Emissions



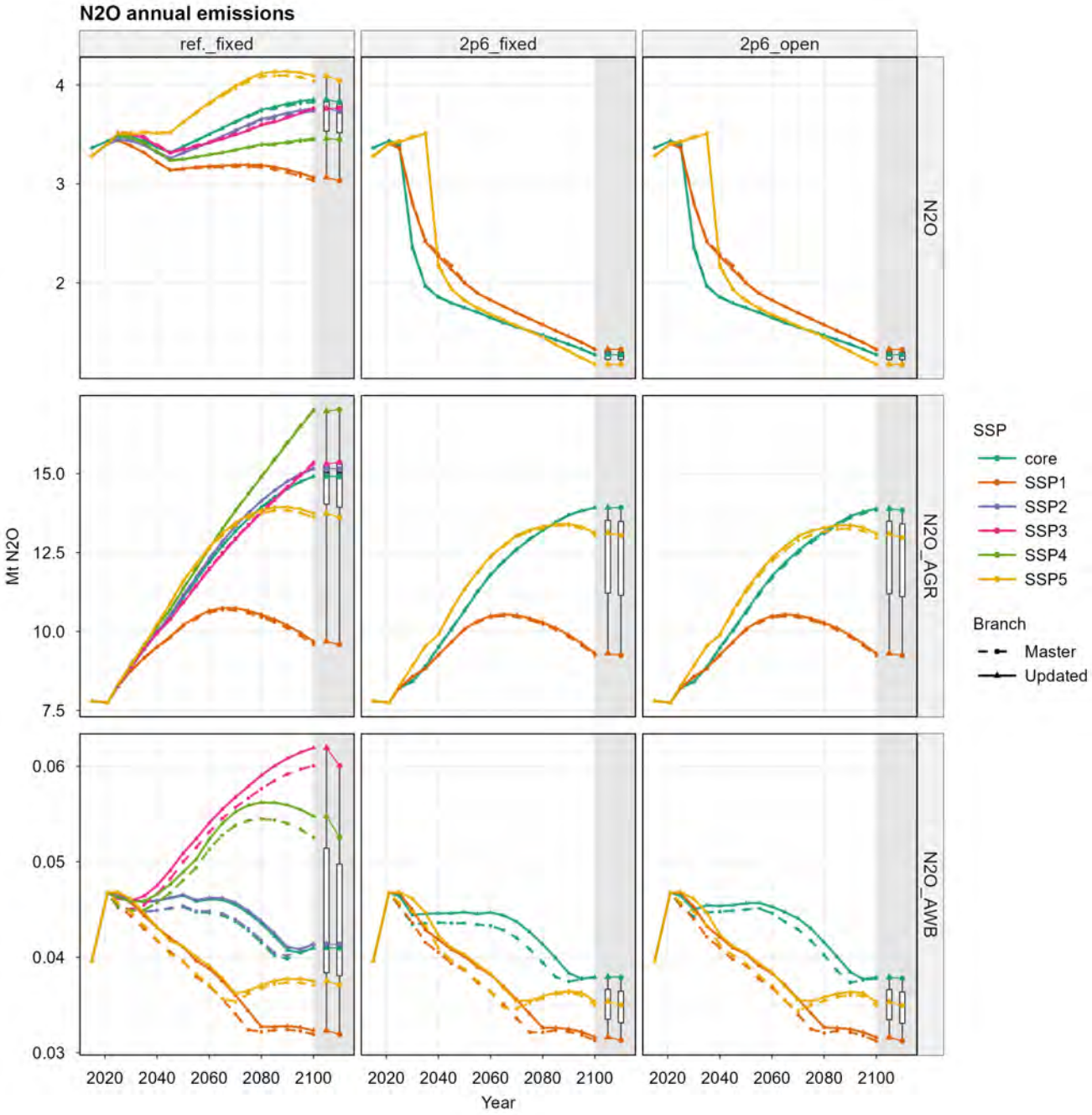
Global energy and industrial processes (EIP) carbon dioxide emissions across SPA and GDP-response (fixed vs. open) scenarios.



Global land use change carbon dioxide emissions across SPA and GDP-response (fixed vs. open) scenarios.



Global CH4 emissions across SPA and GDP-response (fixed vs. open) scenarios. Row panels indicate CH4 emissions by sector: non-Ag (CH4), agriculture (CH4_AGR), and agricultural waste burning (CH4_ABW).



Global N2O emissions across SPA and GDP-response (fixed vs. open) scenarios.Row panels indicate CH4 emissions by sector: non-Ag (CH4), agriculture (CH4_AGR), and agricultural waste burning (CH4_ABW).

Note: Only key figures are indexed. Other sectoral comparisons are not included in the released version of CMP, as the updates had only a minor impact.

5. Summary

This Core Model Proposal delivers a comprehensive restructuring of the macroeconomic and socioeconomic data processing system within GCAM, improving transparency, consistency, and traceability in the GCAM-Macro-KLEM framework. The updates integrate new and revised data sources, clean legacy structures, and enhance alignment across modules, laying a stronger foundation for future developments. While the overall impact of these updates on GCAM's sectoral projections is relatively modest, the changes have a relatively larger effect on macroeconomic outcomes. These shifts reflect improved calibration and internal consistency in the economic system.

Looking ahead, the forthcoming KLEAM version of GCAM-Macro will build on this structure to integrate agriculture into the macroeconomic framework using traceable and transparent data flows. Further efforts will focus on testing and refining key macroeconomic parameters, such as income elasticities and saving–investment parameters, across sectors and regions to improve overall model behavior. In addition, we will maintain a consistent set of key macroeconomic figures extending from historical observations to future projections. These developments will strengthen GCAM-Macro's capacity for broader socioeconomic and policy analyses.

References

Feenstra, R.C., Inklaar, R., Timmer, M.P., 2015. The Next Generation of the Penn World Table. American Economic Review 105, 3150–3182. https://doi.org/10.1257/aer.20130954

Foure, J., Aguiar, A., Bibas, R., Chateau, J., Fujimori, S., Lefevre, J., Leimbach, M., Rey-Los-Santos, L., Valin, H., 2020. Macroeconomic Drivers of Baseline Scenarios in Dynamic CGE models: Review and Guidelines Proposal. Journal of Global Economic Analysis 5, 28–62. https://doi.org/10.21642/JGEA.050102AF

Müller, K., Xu, C., Lehbib, M., Chen, Z., 2025. The Global Macro Database: A New International Macroeconomic Dataset. Working Paper Series. https://doi.org/10.3386/w33714

Patel, P., Edmonds, J., Kim, S., Zhao, X., Sheng, D., Waldhoff, S., Lochner, E., 2023. Core Model Proposal# 332: GCAM Macro-Economic Module (KLEM Version) (No. PNNL-34479). Pacific Northwest National Laboratory, College Park, USA.

Zhao, X., Patel, P., Di, S., Edmonds, J., Waldhoff, S., Fawcett, A., Bertram, C., O'neill, B., 2024. Core Model Proposal #399: Updating the SSP Database (v3.0) (Population, GDP, and Labor Force) and Labor Productivity (KLEM). https://doi.org/10.13140/RG.2.2.26389.54243