Global Economic Impacts of Climate Shocks, Climate Policy and Changes in Climate Risk Assessment

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Based On

- Fernando R., Liu W. and W. McKibbin (2021) “Global Economic Impacts of Climate Shocks, Climate Policy and Changes in Climate Risk Assessment” Brookings Climate and Energy Economics Discussion Paper, March 31, 2021 and CAMA working paper 37/2021
- Revised July 2022

Overview

- Macroeconomic implications of Climate Change
- Modeling Climate Risk
  - The G-Cubed Multi-Country Model
  - Calculating climate and policy shocks
- Results
- Conclusion

Climate Change

- Both the impacts of climate change (physical risk) and the policy responses to climate change (transition risk) have significant macroeconomic implications

What we explore

- the macroeconomic impacts of physical climate risk due to **chronic climate change** associated with global temperature increases and climate-related **extreme shocks**;
- the macroeconomic effects of climate policies designed to transition to net zero emissions by 2050 (transition risk); and
- the potential macroeconomic consequences of changes in risk premia in financial markets associated with increasing concern over climate events.

G-Cubed Model

G-Cubed

- Hybrid of a dynamic stochastic general equilibrium (DSGE) models (used by central banks) and a computable general equilibrium (CGE) model.

- Models Inter-industry linkages, international trade, capital flows, consumption, and investment.

- Annual macroeconomic and sectoral dynamics

- Captures frictions in labor market and capital accumulation
  - Full employment in the long run but unemployment in the short run
  - Labor mobile across sectors but not regions
  - Sector specific quadratic adjustment cost to physical capital

20 Sectors in each region

1	Electricity delivery	**Energy Sectors**
2	Gas Extraction and utilities	
3	Petroleum refining	
4	Coal mining	
5	Crude oil extraction	
6	Construction	**Non- Energy Sectors**
7	Other mining	
8	Agriculture and forestry	
9	Durable goods	
10	Nondurables	
11	Transportation	
12	Services	
13	Coal generation	**Electricity Sectors**
14	Natural gas generation	
15	Petroleum generation	
16	Nuclear generation	
17	Wind generation	
18	Solar generation	
19	Hydroelectric generation	
20	Other generation	

G-Cubed

Modelled

Each country has a fiscal rule for government spending and taxation policy)

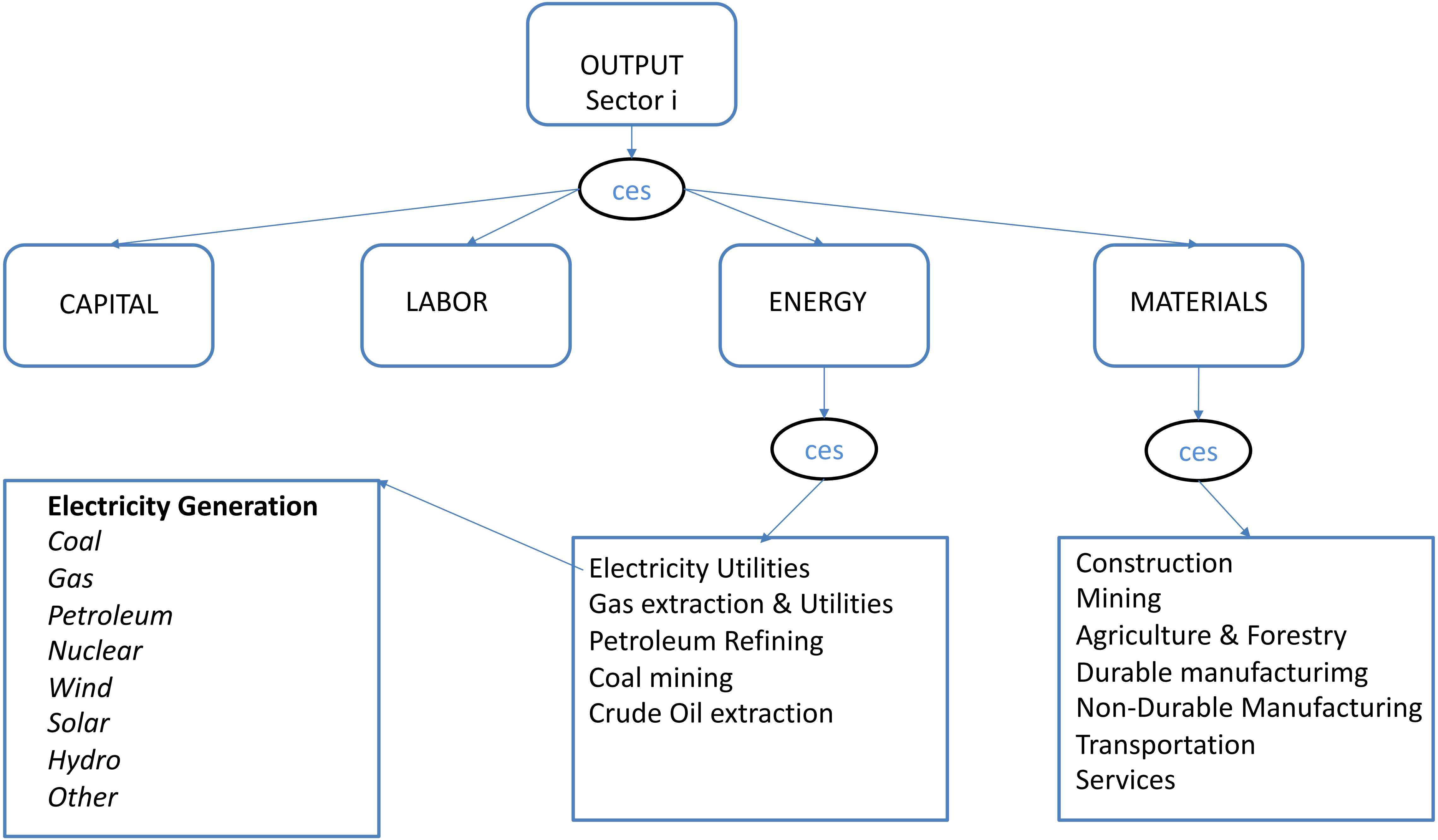
Each country has a monetary rule which shows how interest rates are adjusted to trade off various policy target (inflation, output, exchange rates, nominal income)

Version 20J

- Europe
- China
- Japan
- India
- United States
- Russia
- Australia
- Oil Exporters
- Rest of Advanced Economies
- ROW

Technology at a point in time

- Each good is produced with a KLEM production technology with CES across KLEM and CES nestings of Energy (E) and Materials (M).
- K is fixed in the current period, L,E and M are variable
- We don’t specify a particular technology but represent technologies by the inputs of KLEM


OUTPUT
Sector i
ces
CAPITAL
LABOR
ENERGY
MATERIALS
ces
ces
Electricity Generation
Coal
Gas
Petroleum
Nuclear
Wind
Solar
Hydro
Other
Electricity Utilities
Gas extraction & Utilities
Petroleum Refining
Coal mining
Crude Oil extraction
Construction
Mining
Agriculture & Forestry
Durable manufacturimg
Non-Durable Manufacturing
Transportation
Services

Baseline without significant Climate shocks or policy

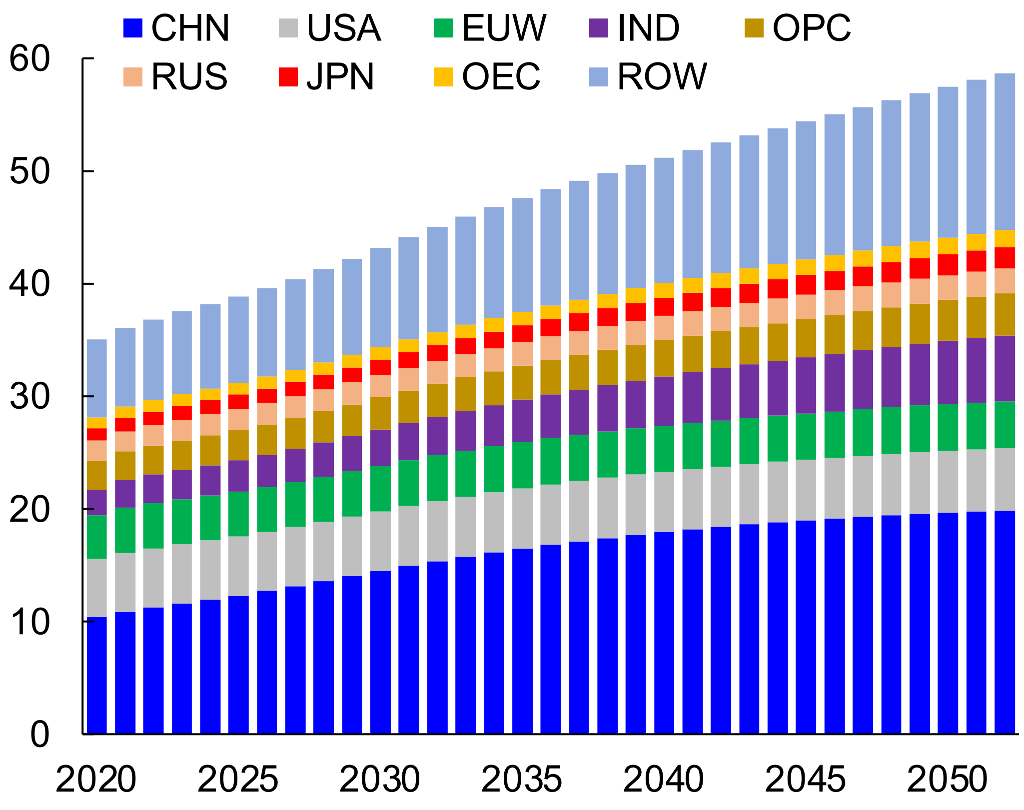
- Using the Groningen Growth and Development 10 sector database, estimate the initial level of productivity in each sector in each economy in 2019.
- Take the ratio of this productivity to the equivalent sector in the United States, which we assume is the frontier.

Baseline without significant climate policy

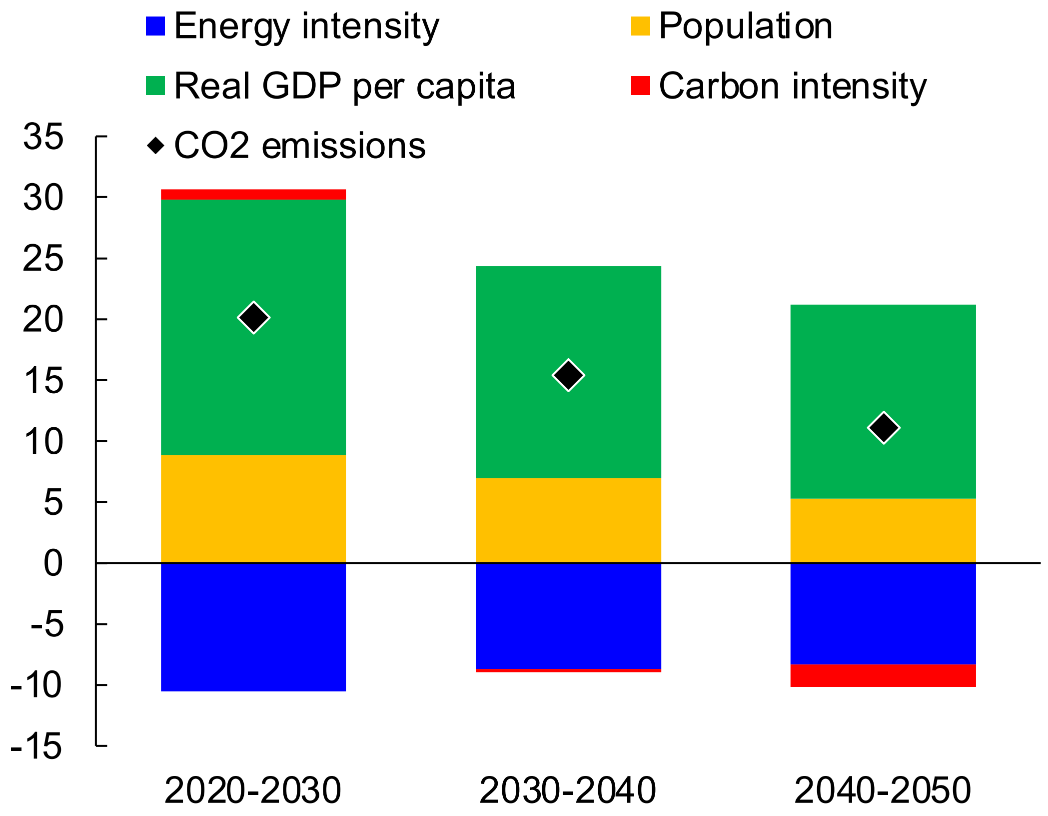
- Given this initial gap in sectoral productivity, and the assumption that each sector in the US has productivity growth of 1.4% per year, use the Barro (2015) catch-up model to generate long term projections of the productivity growth rate of each sector within each country.
- This catchup rate can be varied (over time) if some regions are expected to catch up more quickly to the frontier due to economic reforms (e.g. China) or more slowly to the frontier due to institutional rigidities (e.g. Russia)

Business-as-usual emissions

Business-as-Usual Baseline CO2 Emissions *(Gigatons of CO2)*



Decomposition of the Change in Global CO2 Emissions *(Percent change)*



Source: IMF staff calculations.

Climate Risks

Developing shocks

- physical climate risk due to **chronic climate change** associated with global temperature increases and climate-related **extreme shocks**;
- policies designed to transition to net zero emissions by 2050 (transition risk); and
- the potential macroeconomic consequences of changes in risk premia in financial markets associated with increasing concern over climate events.

Physical Climate risk

- Use four widely used climate scenarios (Representative Concentration Pathways, or RCP)
- Identify the physical damage functions due to chronic climate risks. The chronic climate risks include sea-level rise, crop yield changes, heat-induced impacts on labor, and increased incidence of diseases.
- Estimate the future incidence of climate-related extreme events, including droughts, floods, heat waves, cold waves, storms and wildfires, based on climate variable projections under the climate scenarios.

Table 1: RCP Scenarios

Scenario	Description
RCP 2.6	The peak in radiative forcing at ~3 W/m^2 (~490 ppm CO2 eq) before 2100 and then decline (the selected pathway decreases to 2.6 W/m^2 by 2100). ($< 2^0$ C by 2100)
RCP 4.5	Stabilization without overshoot pathway to 4.5 W/m^2 (~650 ppm CO2 eq) at stabilization after 2100 ($2\ to\ 3^0$C by 2100)
RCP 6.0	Stabilization without overshoot pathway to 6 W/m^2 (~850 ppm CO2 eq) at stabilization after 2100($3\ to\ 4^0$C by 2100)
RCP 8.5	Rising radiative forcing pathway leading to 8.5 W/m^2 (~1370 ppm CO2 eq) by 2100. ($5\ to\ 6^0$C by 2100)

Source: van Vuuren et al (2011)

Damage Functions and Projections for Chronic Climate Change

- **Chronic shocks: Historical impacts: Roson & Sartori 2016**
  - Sea level rise - Land loss
  - Heat-related impacts on labor productivity for Agriculture, Manufacturing, and Services
  - Labour productivity changes due to climate impacts on diseases
  - Agriculture productivity - Maize (GRO), Rice (PDR), Wheat (WHT)
- **Chronic shocks: Projected impacts**
  - Used ISIMIP data for climate variable projections under RCP scenarios to derive the future impacts.

Damage Functions and Projections for Extreme events

- **Extreme shocks: Historical impacts**
- Historical responsiveness of agriculture and energy (including electricity) to extreme events
  - Historical agriculture yields - FAO
  - Historical electricity generation - World Bank
  - Historical energy production - BP
  - Historical disasters - Centre for Research on the Epidemiology of Disasters (CRED)

Damage Functions and Projections for Extreme events

- **Extreme shocks: Projected impacts**
  - Projection of extreme events using ISIMIP data for climate variable projections under RCP scenarios
    - Extreme medium to long-term dry and wet conditions (proxies for droughts and floods)
    - Extreme short-term warm and cold conditions (proxies for heat and cold waves)
    - Wildfires and storms (empirical functions based on historical occurrences of wildfires and storms with changes in temperature)
  - Projection of impacts of extreme events using the empirical estimations

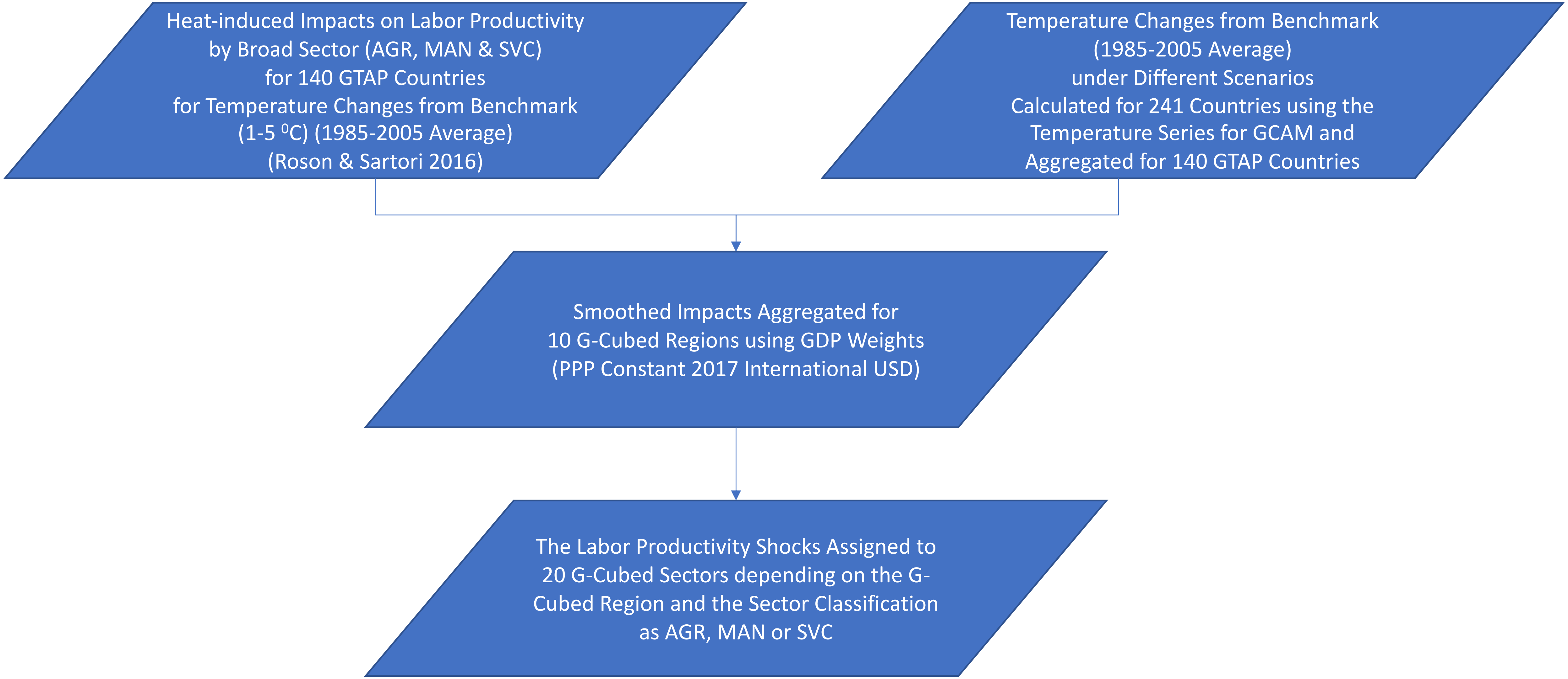
Some limitations

- Intensity indicators for extreme events were not consistently and widely available. Therefore, the duration of extreme events was used as a proxy for intensity.
- The proxies calculated for projected droughts, floods, heatwaves, and coldwaves were intensity measures. But, we used the durations to be consistent with the empirical estimations.
- Implicitly calculating averages when we should use stochastic simulations under different assumptions about the nature of the probability distributions of the shocks and better explore the outliers.

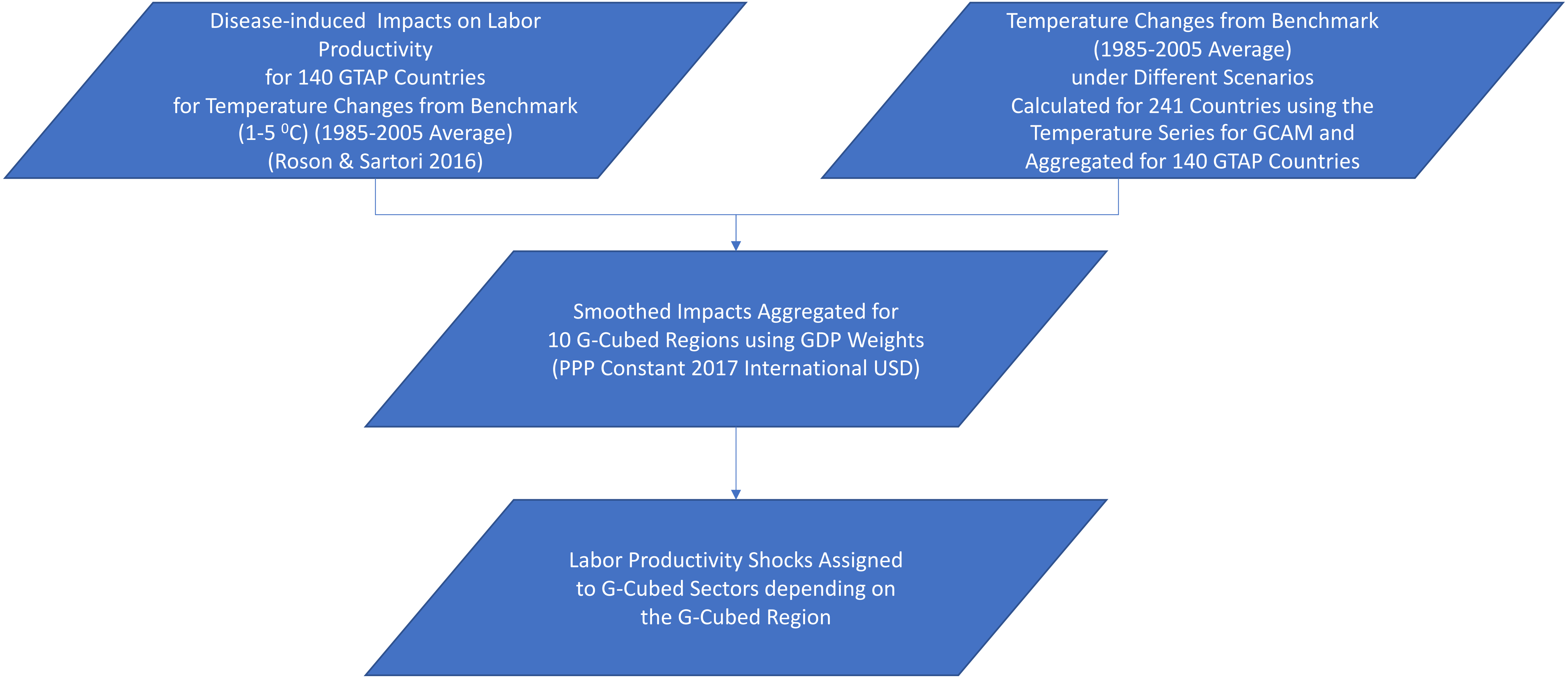
Shocks for Physical climate risk

- Chronic climate change
  - Shocks to sectoral productivity
  - Shocks to labour supply
- Extreme climate events
  - Shocks to sectoral productivity
  - Shocks to labour supply

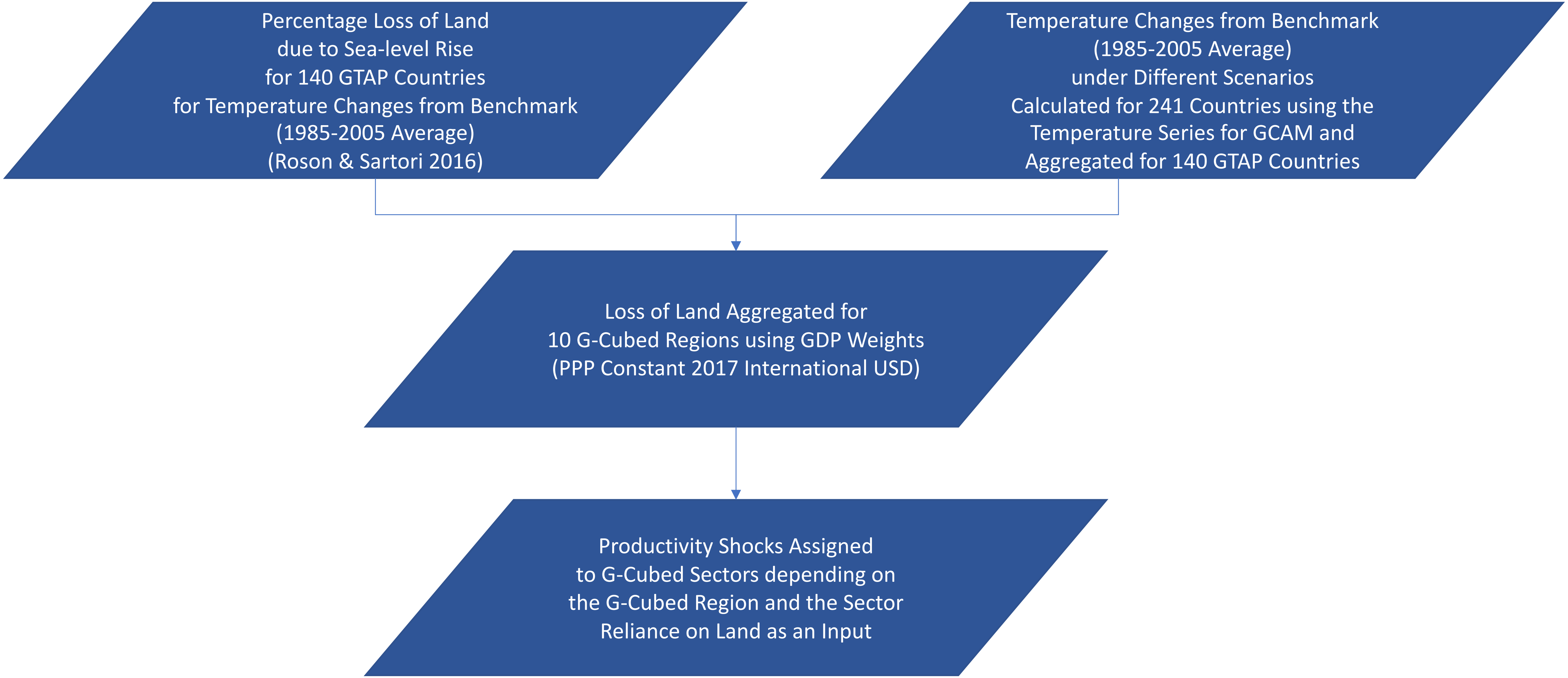
Heat-induced Impacts on Labor Productivity



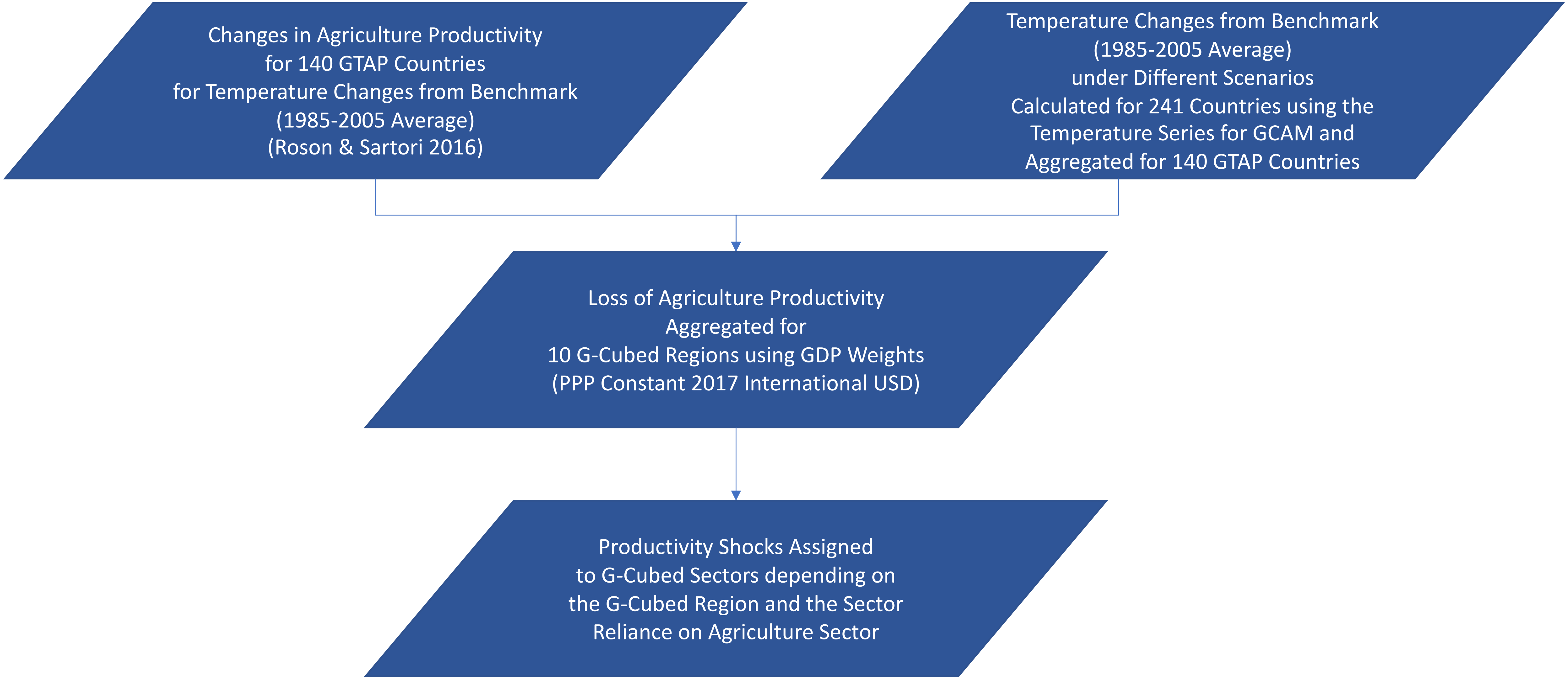
Disease-induced Impacts on Labor Productivity



Sea-level Rise Impacts on Sector Productivity



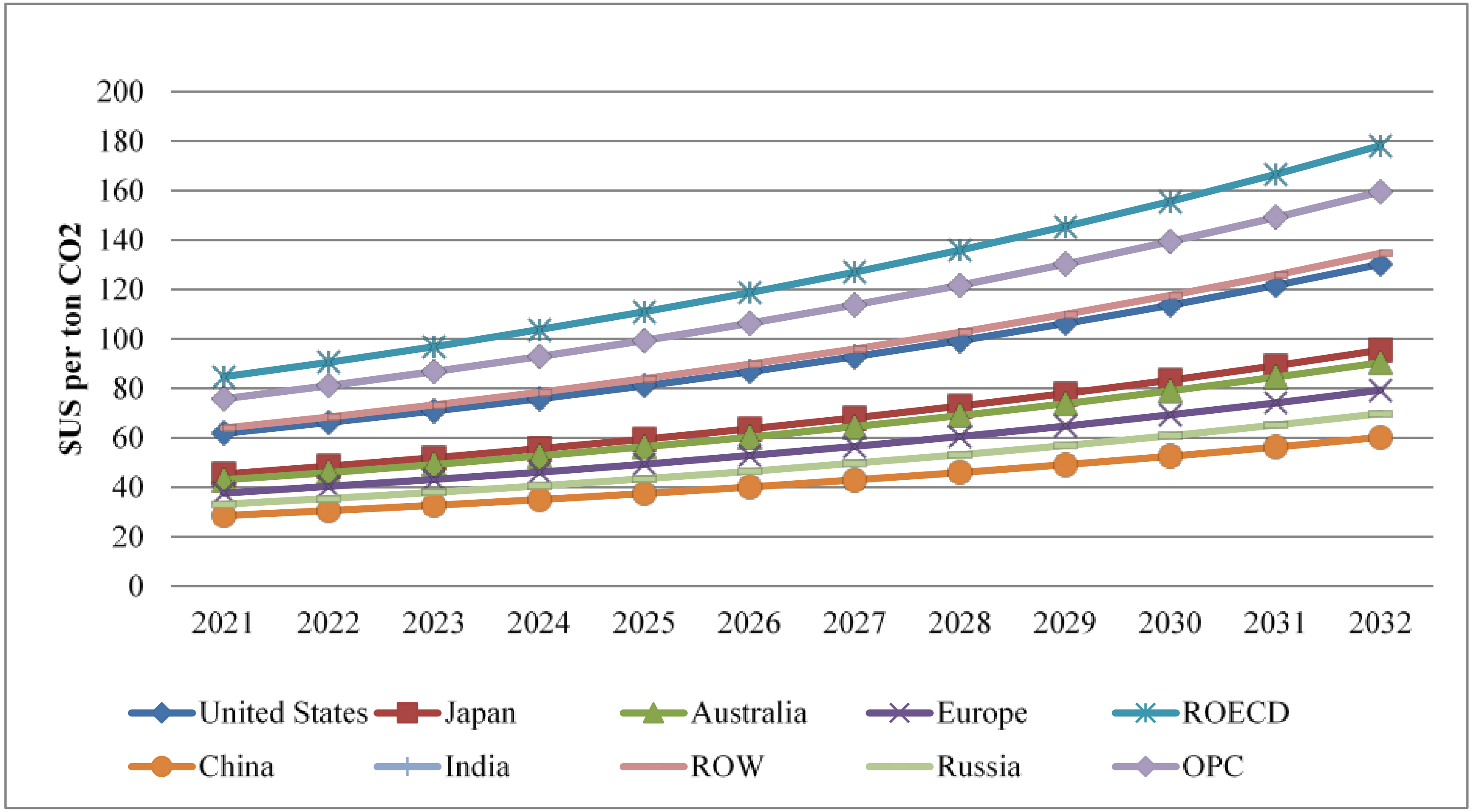
Impacts on Agriculture Productivity and Spill over Impacts to other Sectors



Transition Risk

- Impact of achieving net zero emissions by 2050 using country specific carbon taxes.
- Different to the IMF WEO results (using the same model) which have a package of policies including green infrastructure in addition to the carbon tax
  - Carbon taxes are bigger when they have to do all the abatement

Figure 2: Carbon Tax per Unit of CO2



Changes in risk premia

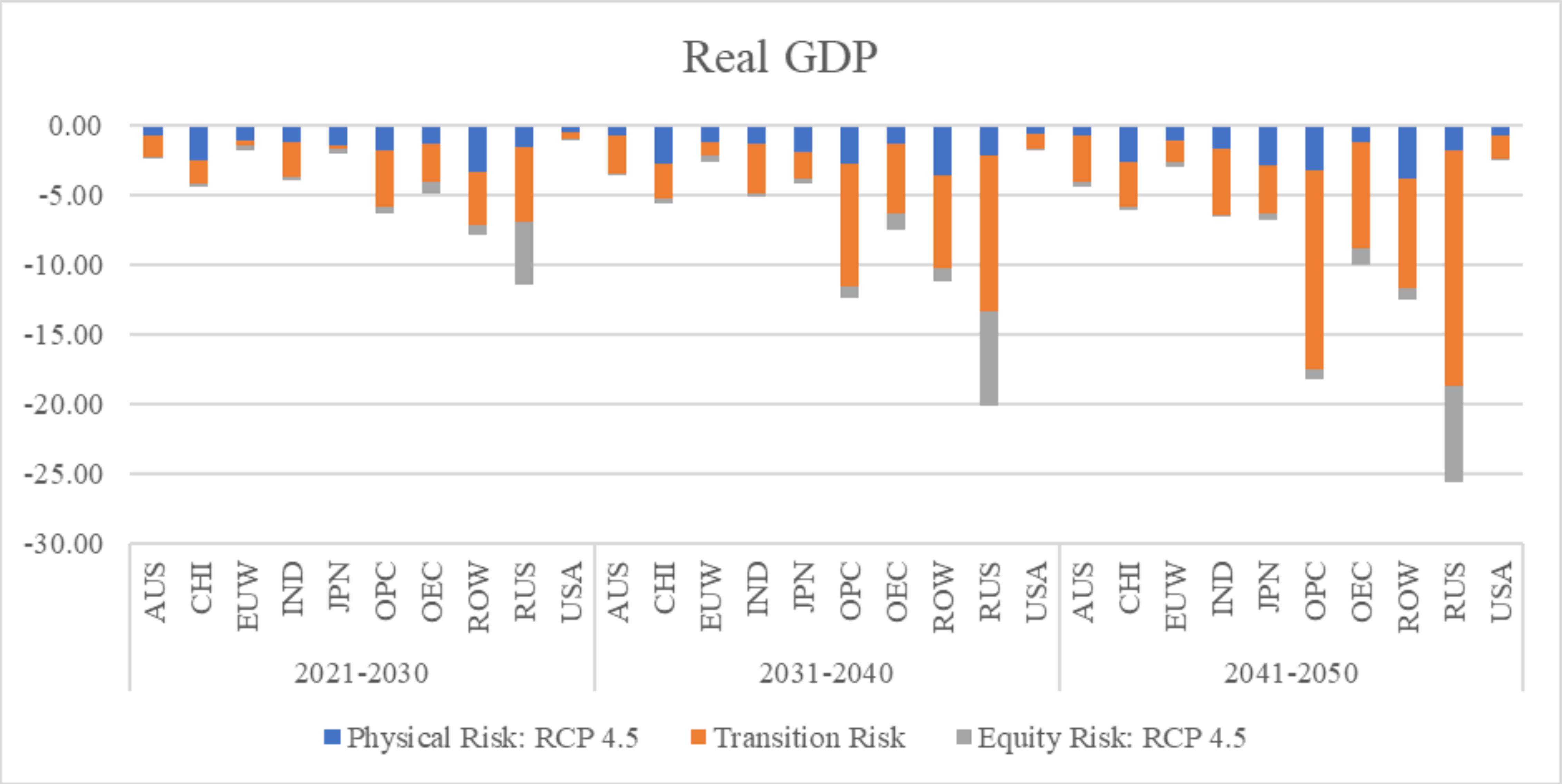
- We calculate shocks to financial risk premia based on relationships between historical climate shocks and changes in financial market risk premia.
- We apply these shocks to risk premia under the RCP scenarios and find that the cost of rising risk premia can be of a magnitude consistent with historical experience

Summary of results

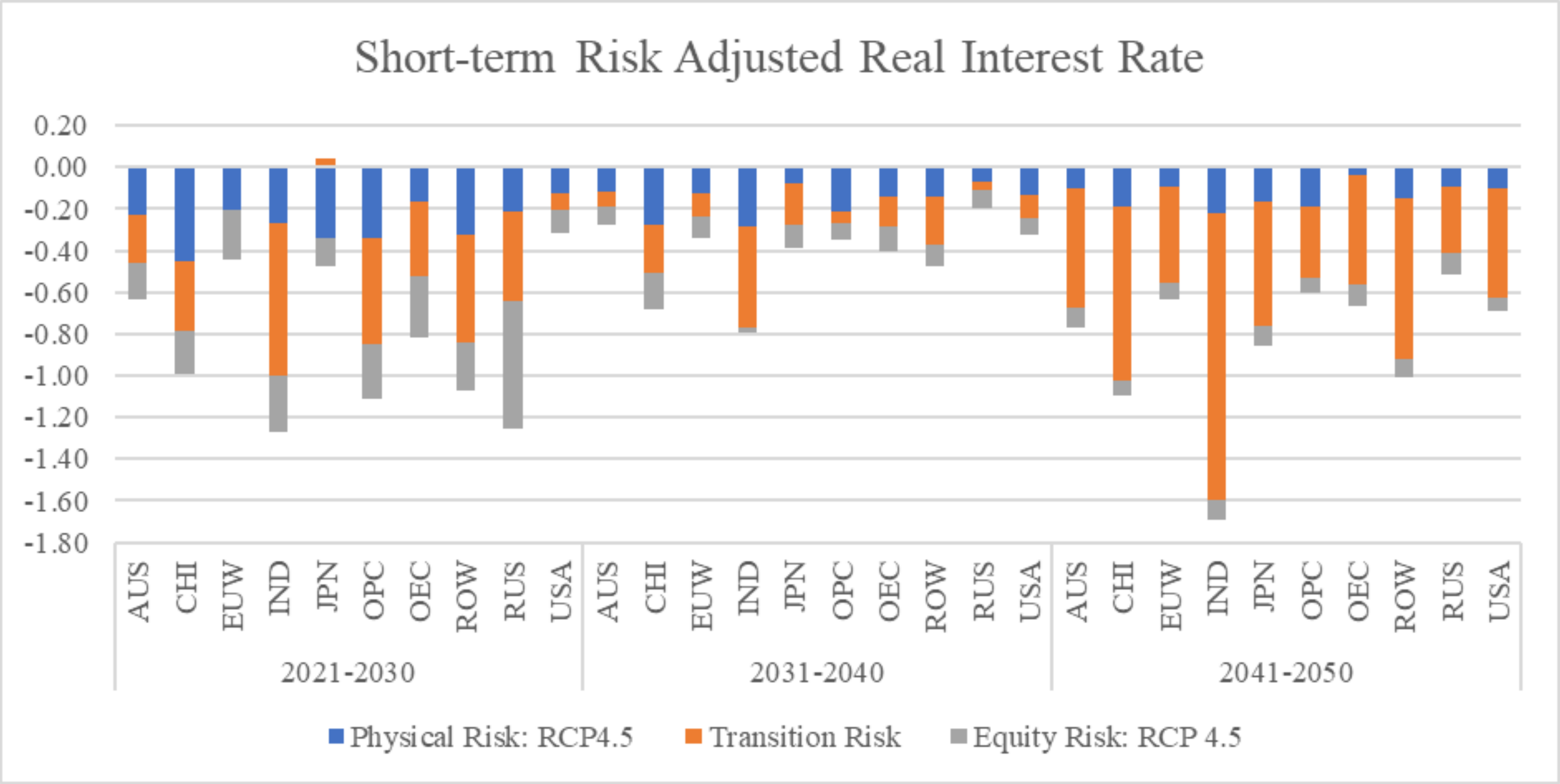
Real GDP

R*

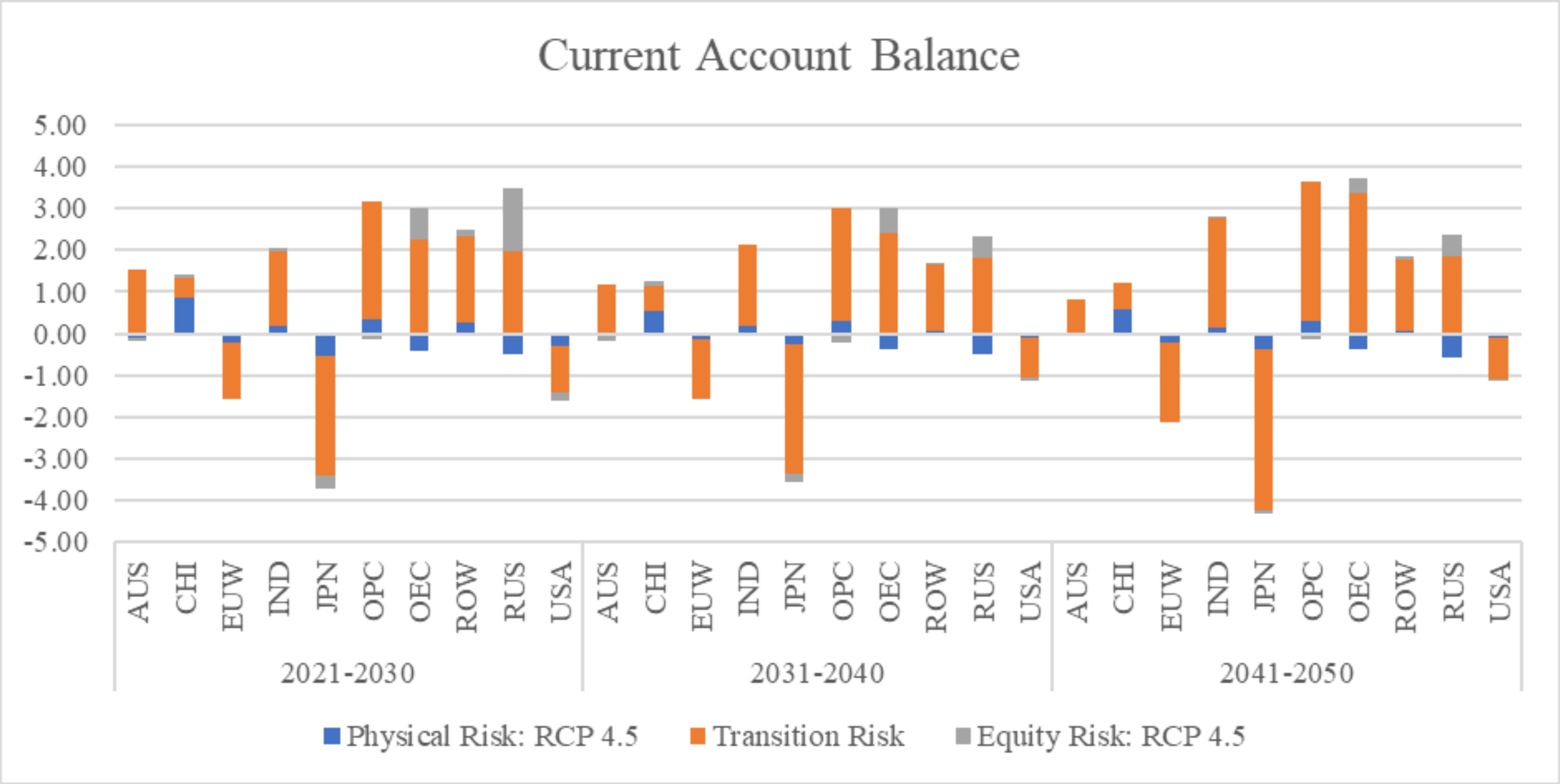
Trade flows



Real GDP
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
AUS
CHI
EUW
IND
JPN
OPC
OEC
ROW
RUS
USA
2021-2030
2031-2040
2041-2050
Physical Risk: RCP 4.5
Transition Risk
Equity Risk: RCP 4.5



Short-term Risk Adjusted Real Interest Rate
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
-1.80
AUS CHI EUW IND JPN OPC OEC ROW RUS USA
2021-2030
2031-2040
2041-2050
Physical Risk: RCP4.5
Transition Risk
Equity Risk: RCP 4.5


Current Account Balance
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
AUS
CHI
EUW
IND
JPN
OPC
OEC
ROW
RUS
USA
2021-2030
2031-2040
2041-2050
Physical Risk: RCP 4.5
Transition Risk
Equity Risk: RCP 4.5

Further information on G-Cubed

www.gcubed.com