Supporting Material for

Temporal and spatial distribution of global mitigation cost: INDCs and generational equity

Contents:

1 Region classification

SM Table 1 Region classification

Region	AIM/CGE classification
Industrial countries	United States
	EU25
	Oceania
	Japan
	Canada
Transition countries	Rest of Europe
	Turkey
	China
	India
	Brazil
	Former Soviet Union
Developing countries	Southeast Asia
	Rest of Asia
	Rest of South America
	Middle East
	North Africa
	Rest of Africa

2 Emission constraints for INDCs

We have taken the INDC information from the webpage [1] and translated this into emissions constraints in the model. We constructed the 2030 emissions targets and then linearly connected these with 2020 emissions. For those countries declaring their target year as 2025 (e.g., the United States), we produced the emissions constraints for 2025 and then calculated the emissions reduction rate from 2020 to 2025. Finally, we adopted that reduction rate from 2025 to 2030.

There are ten types of commitments, as shown in SM Table 1. The emissions coverage is focused on GHGs or CO2,¬ and some countries use emissions intensity. The reference diverges from 1990 to 2014, and some countries also use the baseline. In cases where we used a reference year before 2005, which is the base year in our model simulation, we used the EDGAR4.2 emissions inventory to determine the emissions target. For those countries that use the year after 2005 as the reference year, we used the emissions results from the baseline scenario. The GDP in 2030 was used for the intensity cases. There are some counties that use specific sector emissions targets, but we ignored these special cases because it would have been too challenging to use model analysis in such instances; these cases also account for a tiny proportion of total global emissions. If countries are treated as a single region in the model (like Japan and China), there is no problem with case 7 because we obtain an identical baseline scenario. However, if the countries are aggregated into a region (e.g., the rest of Asia), we need to derive baseline emissions for such countries. In order to do so, assuming that we have GDP assumptions for every country, we used the baseline scenario's emissions intensity change in the aggregated region. Then, GDP and emissions intensity changes for each country were used to derive the emissions for the baseline scenario.

SM Table 2 List of INDC commitment patterns

Case	Emissions	Reference	Data source and assumption
1	GHG Emissions	1990	Based on EDGAR4.2
2	GHG Emissions	1994	
3	GHG Emissions	2000	
4	GHG Emissions	2005	
5	GHG Emissions	2010	Based on emissions in the reference year of baseline scenario and GDP in 2030
6	GHG Emissions	2014	
7	GHG Emissions	baseline	Based on baseline scenario
8	GHG Emissions intensity	2005	Based on EDGAR4.2 and GDP in 2030
9	CO2 Emissions intensity	2005	
10	GHG Emissions intensity	2007	Based on baseline scenario
11	GHG Emissions intensity	2010	
12	GHG Emissions intensity	baseline	

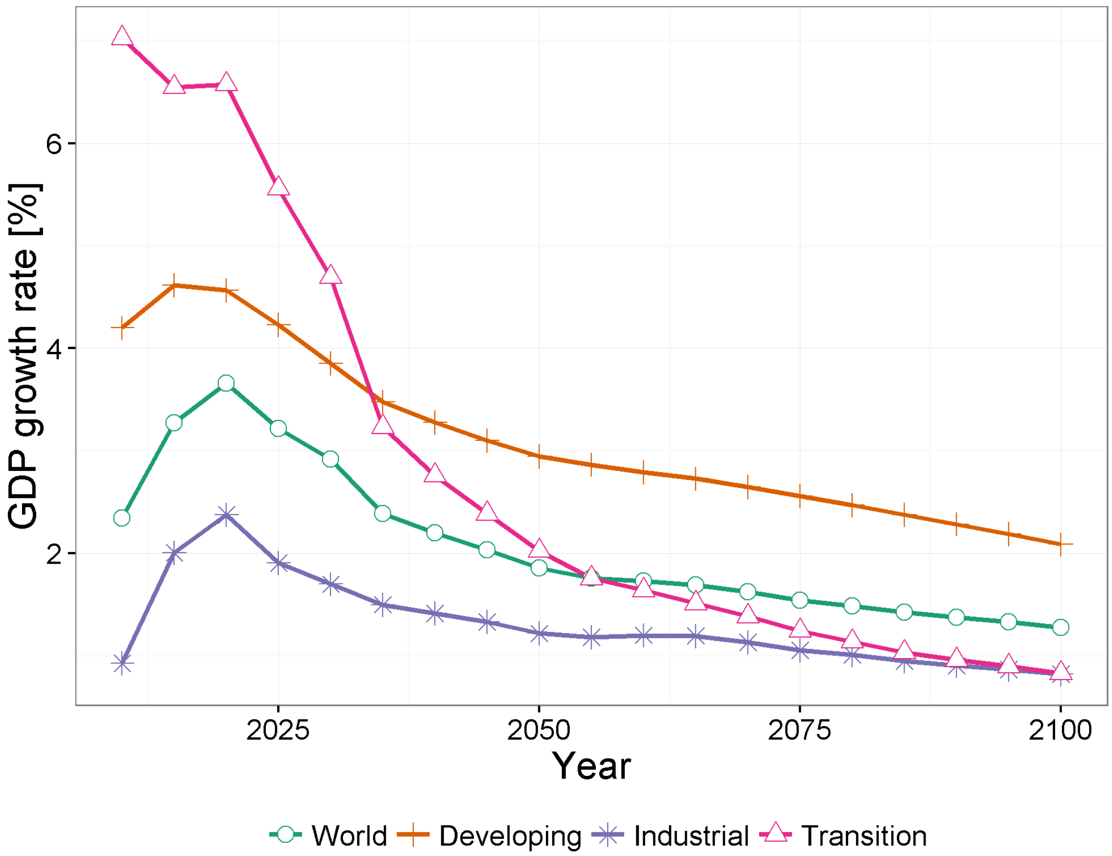
3 Emission pathway assumptions

Our modeling framework assumed exogenous emissions pathways for both scenarios. The determination of emissions pathways is based on the following equation:

$$x_t = z_t + y_{t0} - \beta(t - 2020)^{\alpha}$$

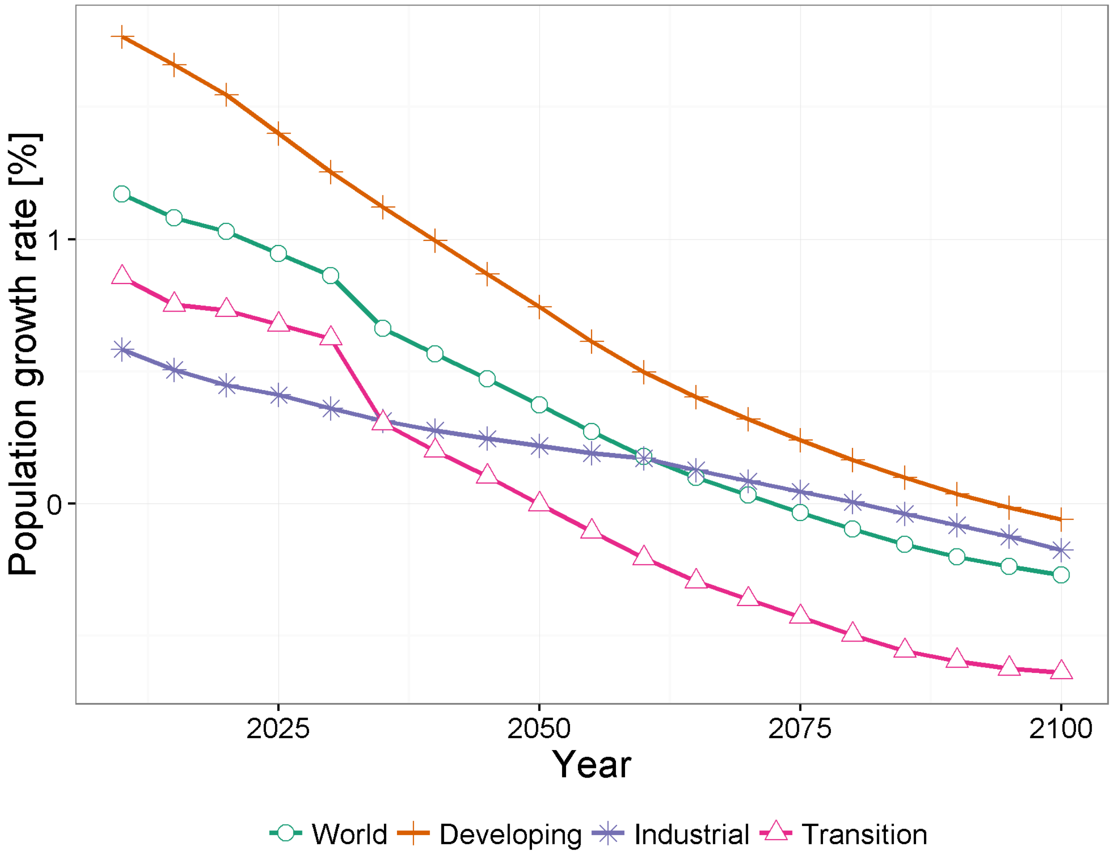
where x_t, and z_t are the global GHG emissions in year t, under 450CO2e and INDC450CO2e scenarios. y_{t0} is the emissions gap between 450CO2e and INDC450CO2e in the year 2030. α (prescribed 0.5) and β are parameters. β is derived from the emissions integral so that the cumulative emissions are same.

4 GDP growth rate



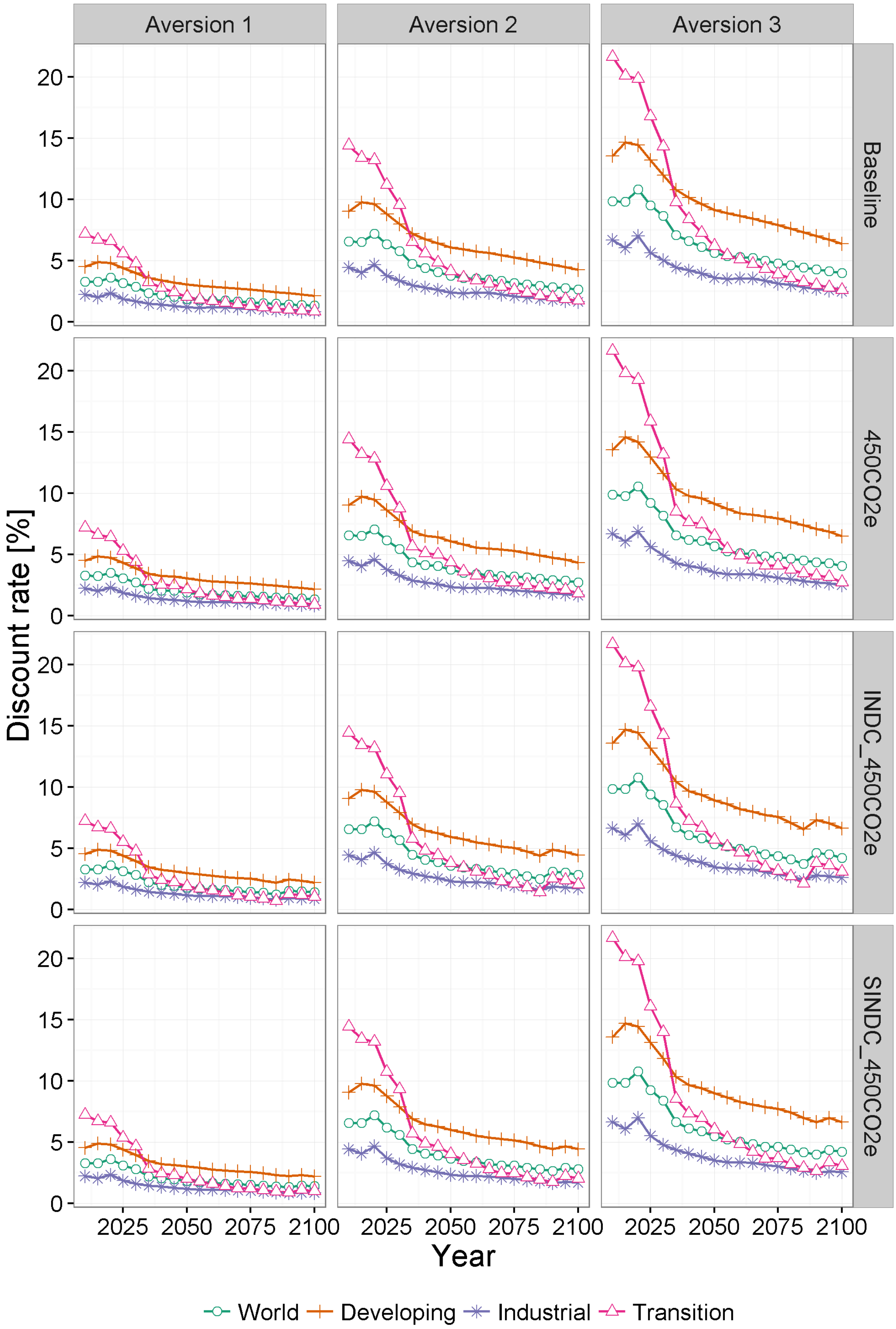
SM Figure 1 Global and regional GDP growth rate through 2100

5 Population growth rate



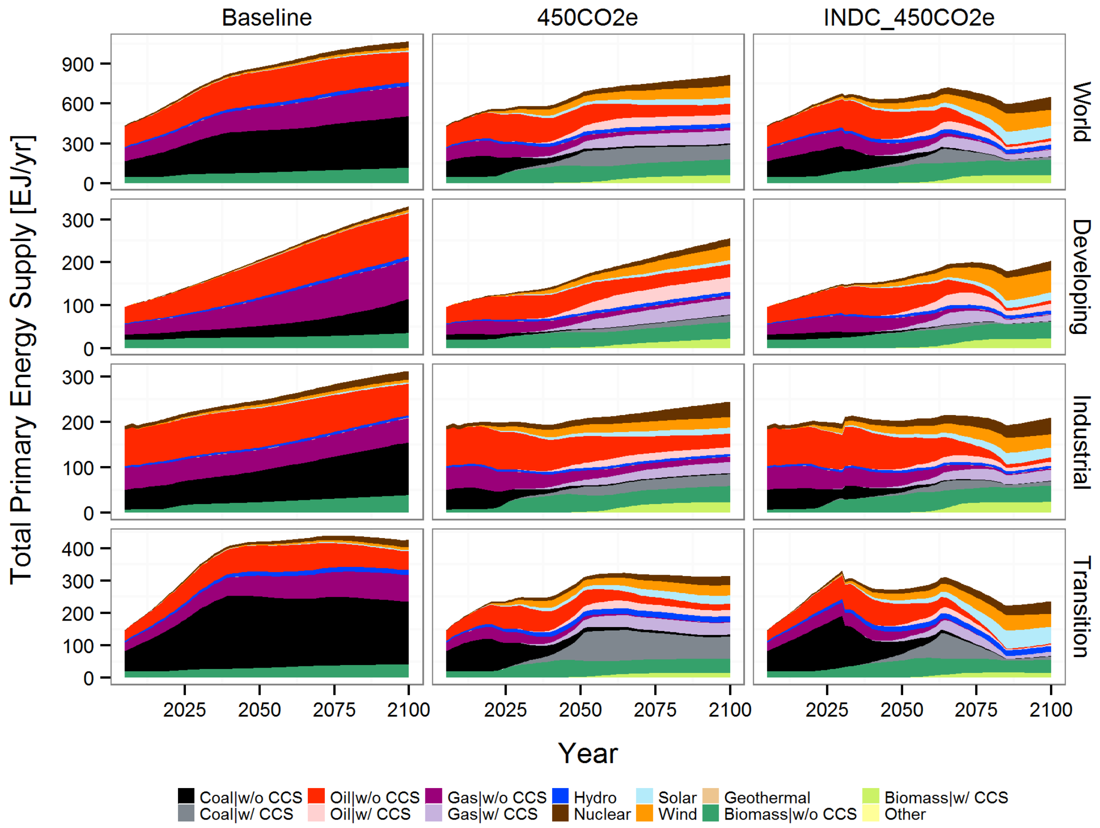
SM Figure 2 Global and regional population growth rate through 2100

6 Discount rate for all scenarios


Aversion 1
Aversion 2
Aversion 3
Baseline
450CO2e
INDC_450CO2e
SINDC_450CO2e
Discount rate [%]
0
5
10
15
20
2025
2050
2075
2100
Year
World
Developing
Industrial
Transition

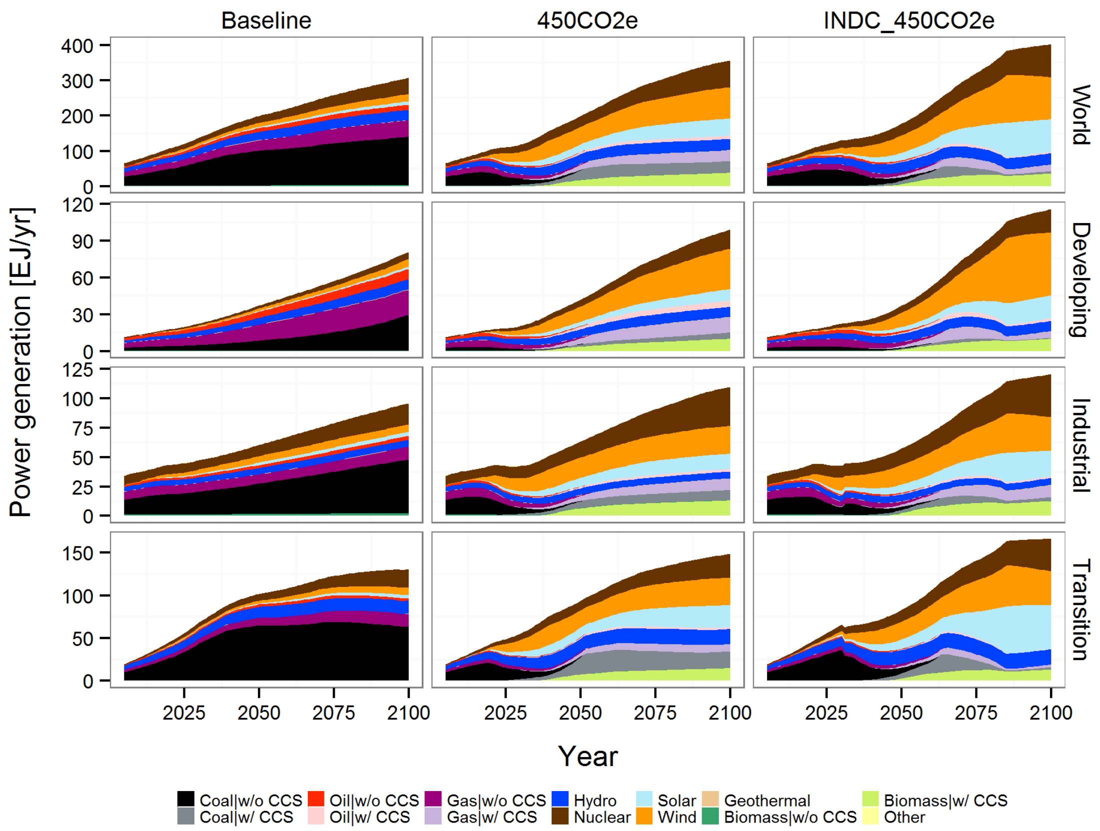
SM Figure 3 Global and regional discount rates for inequality aversions of 1, 2, and 3 in the Baseline, 450CO2e, INDC_450CO2e and SINDC_450CO2e scenarios.

7 Total primary energy supply



SM Figure 4 Global and regional primary energy supply by energy sources through 2100 for scenarios Baseline, 450CO2e and INDC_450CO2e.

8 Electricity generation



SM Figure 5 Global and regional power generation by energy sources through 2100 for scenarios Baseline, 450CO2e and INDC_450CO2e.

9 Regression equation in inter-regional analysis

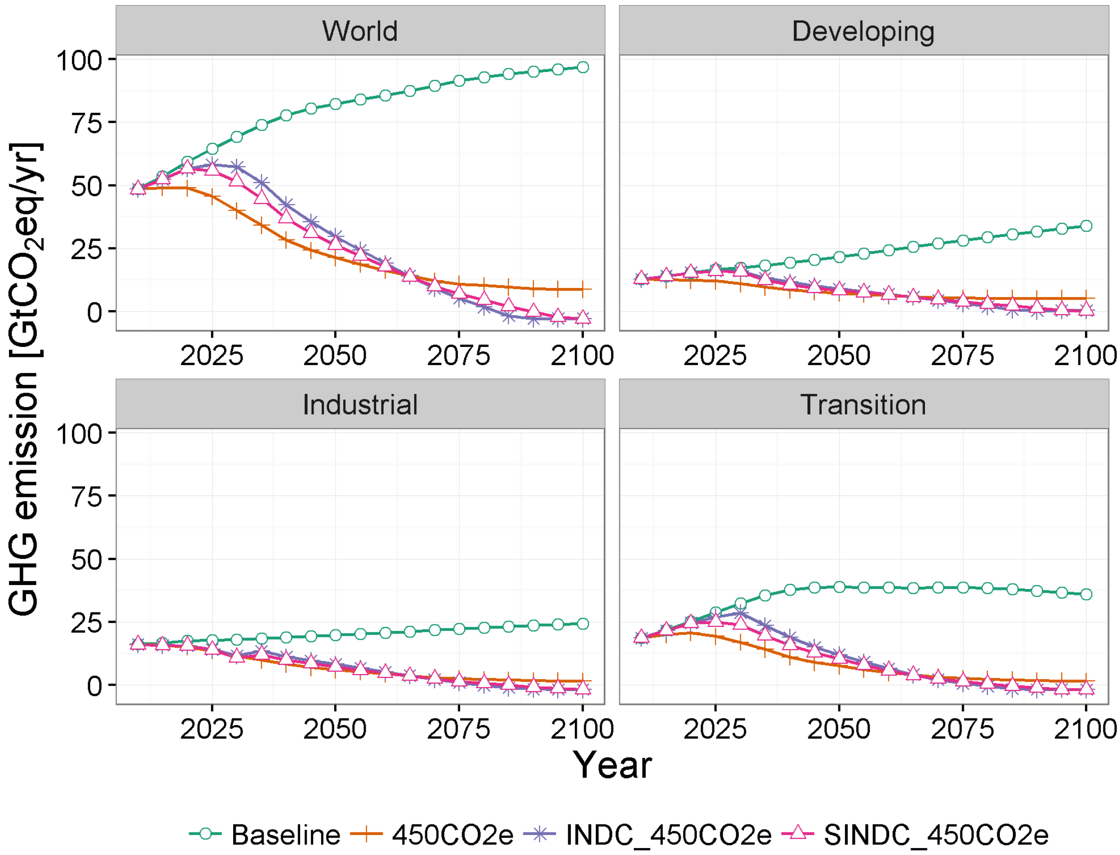
The regression used for the analysis defines the relationship between income per capita and consumption loss. The equation is as follows:

$$Y_r = aX_r + b$$

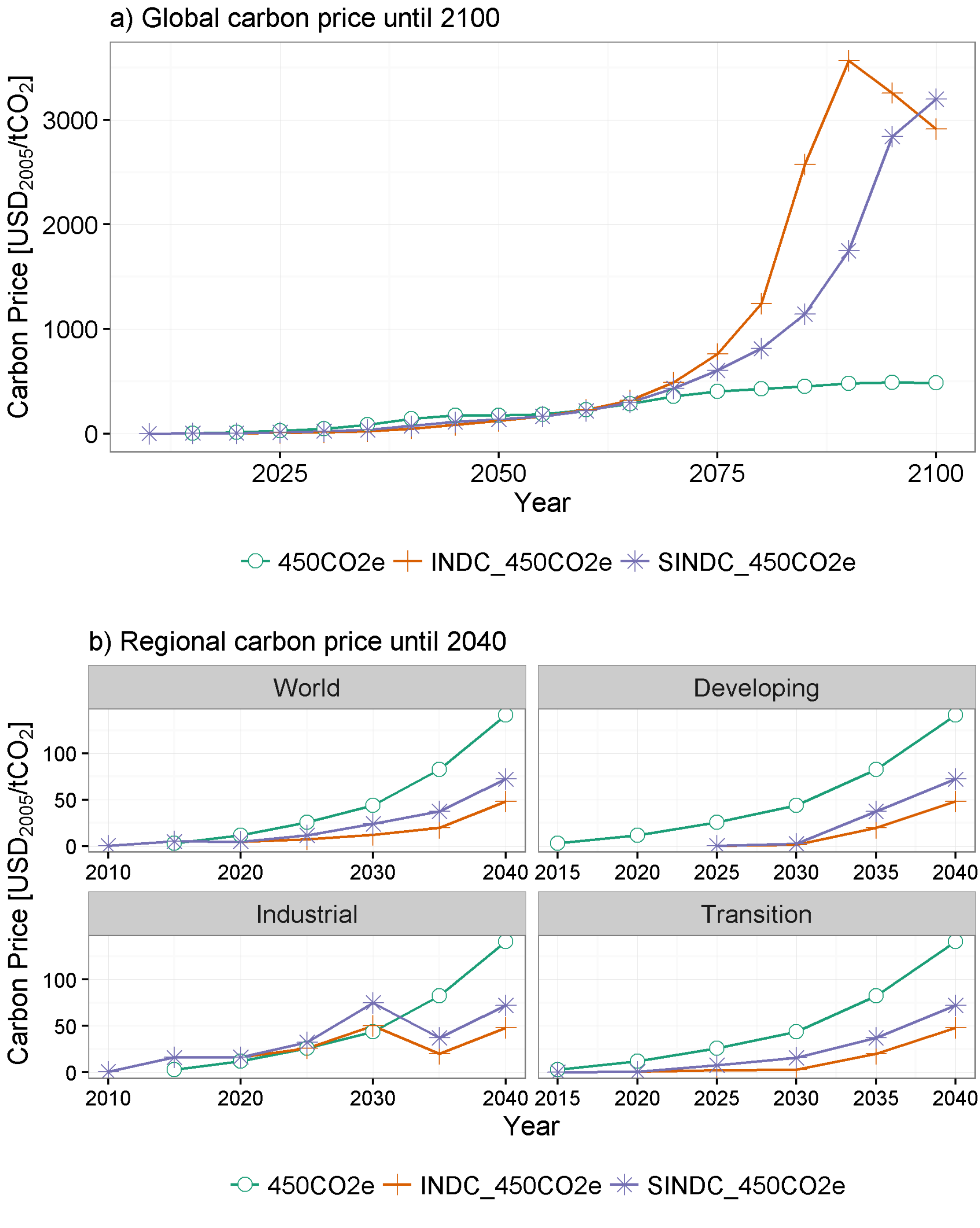
where Y_r is consumption loss rate and X_r is income per capita for each region r; a and b are regressed parameters. Figures 6, 7, and 9 present the situation where Y_r differs.

For Figure 6, consumption loss was accounted for as net present value discounted by three different aversion parameter assumptions (1, 2, and 3) as Y_r. For Figure 7, each undiscounted year's consumption loss was regressed for each year for Y_r. For Figure 9, we used multiple risk aversion parameters for consumption loss and accounted for them as the net present value as Y_r.

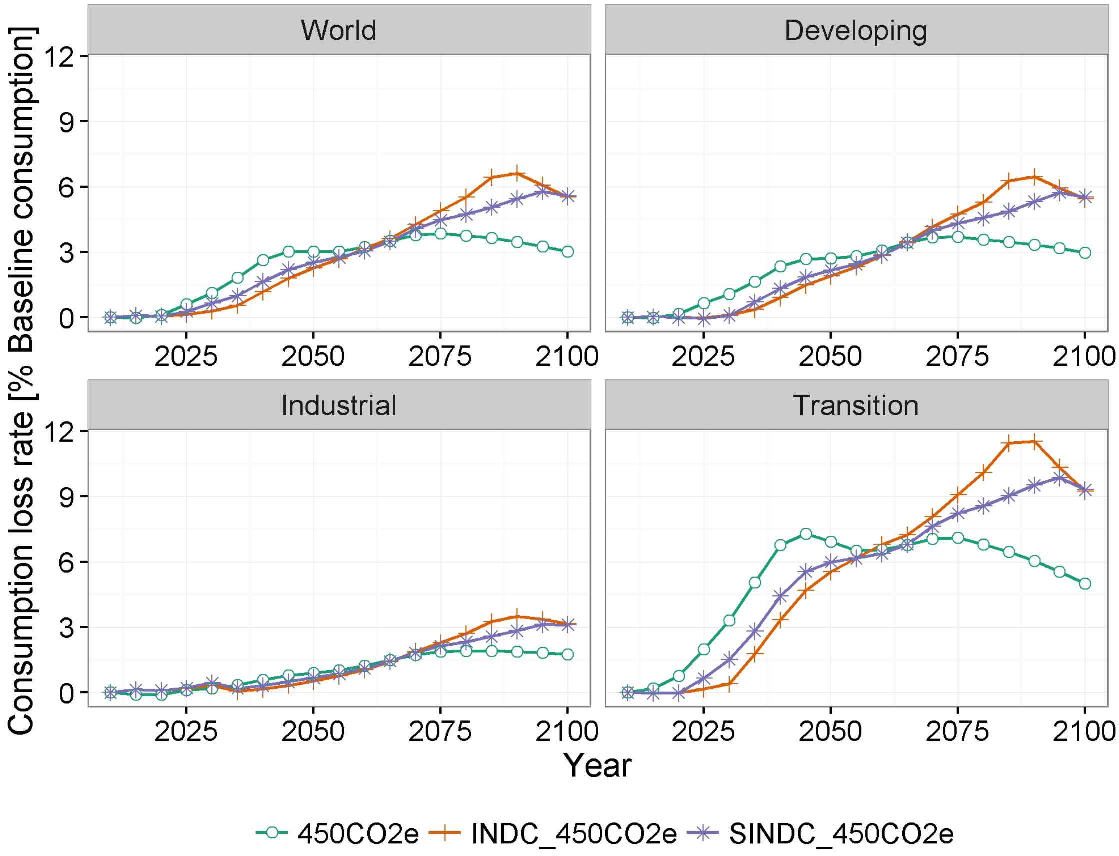
10 Figures for SINDC_450CO2e scenario



SM Figure 6 Global and regional GHG emission paths for scenarios Baseline, 450CO2e, INDC_450CO2e and SINDC_450CO2e.



SM Figure 7 (a) Global carbon price through 2100 and (b) regional carbon price through 2040 for scenarios 450CO2e, INDC_450CO2e and SINDC_450CO2e.



SM Figure 8 Global and regional mitigation costs for scenarios 450CO2e, INDC_450CO2e and SINDC_450CO2e.

References

1. United Nations Frameowrk Convention on Climate Change, (UNFCCC). *INDCs as communicated by Parties*. 2016; Available from: http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx.