INDIA IN THE COMING 'CLIMATE G2'?

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APPENDIX A. SUPPLEMENTAL INFORMATION

Emissions pathways and BAU

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Table A1. Emissions pathways for different allocations, including 2030 global emissions targets ($GtCO_2$)

	USA	EU-27	China	India	Canada	CIS	Latin America	Rest of Europe	Rest of Asia	Austral-asia	Middle East	Africa	**World**
Equal per capita scenario with total global 2030 fossil CO_2 emissions of 20 Gt (EpC20Gt)													
2015	4.8	3.3	9.1	2.3	0.5	2.4	1.8	0.5	3.7	0.4	1.9	1.2	**32**
2020	3.8	2.7	9.4	2.9	0.4	2.3	2.0	0.4	3.8	0.4	1.9	1.6	**32**
2025	2.5	2.1	7.8	3.4	0.3	1.7	2.0	0.3	3.8	0.3	1.6	2.4	**28**
2030	0.9	1.2	3.6	3.6	0.1	0.7	1.8	0.1	3.6	0.1	0.7	3.6	**20**
2035	0.6	0.9	2.7	4.1	0.1	0.5	1.8	0.1	3.5	0.1	0.5	4.0	**19**
2040	0.3	0.6	1.9	4.6	0.0	0.3	1.7	0.1	3.5	0.0	0.4	4.4	**18**
Billion high emitter scenario with total global 2030 fossil CO_2 emissions of 20 Gt (BHE20Gt)													
2015	4.8	3.4	9.1	2.3	0.5	2.5	1.8	0.5	3.7	0.4	1.9	1.1	**32**
2020	3.9	3.1	9.8	2.6	0.4	2.4	2.0	0.4	3.7	0.4	2.0	1.2	**32**
2025	2.9	2.7	8.8	2.7	0.3	2.0	1.9	0.4	3.4	0.3	1.8	1.2	**28**
2030	1.7	2.3	5.6	2.1	0.2	1.3	1.6	0.2	2.6	0.1	1.0	1.2	**20**
2035	1.2	1.9	4.7	2.0	0.2	1.1	1.5	0.2	2.3	0.1	0.8	1.2	**17**
2040	0.8	1.7	3.7	1.8	0.1	0.8	1.4	0.1	2.0	0.0	0.6	1.2	**14**
Billion high emitter scenario with poverty alleviation with total global 2030 fossil CO_2 emissions of 20 Gt (BHE(P)20Gt)													
2015	4.8	3.3	9.1	2.3	0.5	2.5	1.8	0.5	3.7	0.4	1.9	1.1	**32**
2020	3.9	2.9	9.7	2.7	0.4	2.3	2.0	0.4	3.7	0.4	2.0	1.3	**32**
2025	2.8	2.5	8.6	2.7	0.3	1.9	2.0	0.3	3.4	0.3	1.7	1.6	**28**
2030	1.5	1.9	5.2	2.2	0.2	1.1	1.7	0.2	2.8	0.1	0.9	2.0	**20**
2035	1.0	1.6	4.3	2.1	0.2	0.9	1.6	0.2	2.5	0.1	0.7	2.4	**17**
2040	0.7	1.2	3.3	2.0	0.1	0.6	1.6	0.1	2.2	0.0	0.5	3.0	**15**
Billion high emitter scenario with total global 2030 fossil CO_2 emissions of 25 Gt (BHE25Gt)													
2015	4.9	3.5	9.2	2.3	0.5	2.5	1.8	0.5	3.7	0.4	1.9	1.1	**32**
2020	4.3	3.3	10.0	2.7	0.5	2.4	2.0	0.5	3.8	0.4	2.0	1.2	**33**
2025	3.5	3.1	9.5	2.7	0.4	2.2	2.1	0.4	3.6	0.3	1.8	1.3	**31**
2030	2.5	3.0	7.2	2.2	0.3	1.7	1.9	0.3	3.2	0.2	1.2	1.3	**25**
2035	2.0	2.8	6.4	2.1	0.3	1.6	1.9	0.3	3.0	0.2	1.0	1.4	**23**
2040	1.5	2.6	5.7	2.0	0.2	1.3	1.9	0.2	2.8	0.1	0.8	1.4	**21**
Billion high emitter scenario with poverty alleviation with total global 2030 fossil CO_2 emissions of 25 Gt (BHE(P)25Gt)													
2015	4.9	3.4	9.2	2.3	0.5	2.5	1.8	0.5	3.7	0.4	1.9	1.1	**32**
2020	4.2	3.2	10.0	2.7	0.4	2.4	2.0	0.4	3.8	0.4	2.0	1.4	**33**
2025	3.4	3.0	9.3	2.7	0.3	2.2	2.1	0.4	3.7	0.3	1.8	1.7	**31**
2030	2.3	2.8	6.7	2.3	0.2	1.6	1.9	0.3	3.4	0.2	1.1	2.1	**25**
2035	1.8	2.6	5.9	2.2	0.2	1.4	1.9	0.3	3.3	0.2	0.9	2.6	**23**
2040	1.3	2.4	5.0	2.1	0.1	1.2	1.9	0.2	3.1	0.1	0.7	3.2	**21**
Billion high emitter scenario with total global 2030 fossil CO_2 emissions of 30 Gt (BHE30Gt)													
2015	5.1	3.5	9.2	2.3	0.5	2.5	1.8	0.5	3.7	0.4	1.9	1.1	**33**
2020	4.7	3.5	10.3	2.7	0.5	2.5	2.1	0.5	3.9	0.4	2.1	1.2	**34**
2025	4.2	3.6	10.2	2.7	0.4	2.4	2.2	0.4	3.9	0.4	1.9	1.3	**34**
2030	3.6	3.7	8.5	2.2	0.4	2.2	2.2	0.4	3.8	0.3	1.4	1.4	**30**
2035	3.2	3.7	8.0	2.1	0.4	2.1	2.3	0.4	3.8	0.3	1.2	1.5	**29**
2040	2.8	3.8	7.5	2.0	0.3	2.0	2.4	0.3	3.8	0.2	1.1	1.6	**28**
Billion high emitter scenario with poverty alleviation with total global 2030 fossil CO_2 emissions of 30 Gt (BHE(P)30Gt)													
2015	5.0	3.5	9.2	2.3	0.5	2.5	1.8	0.5	3.7	0.4	1.9	1.1	**32**
2020	4.5	3.4	10.2	2.7	0.5	2.5	2.0	0.5	3.9	0.4	2.1	1.4	**34**
2025	3.9	3.4	10.0	2.7	0.4	2.4	2.2	0.4	4.0	0.4	1.9	1.7	**33**
2030	3.2	3.5	8.2	2.3	0.3	2.1	2.1	0.4	3.9	0.3	1.4	2.2	**30**
2035	2.7	3.5	7.6	2.2	0.3	1.9	2.2	0.3	3.9	0.3	1.2	2.8	**29**
2040	2.3	3.4	7.0	2.1	0.2	1.7	2.2	0.3	4.0	0.2	1.1	3.5	**28**
Grandfathered scenario with total global 2030 fossil CO_2 emissions of 20 Gt (G20Gt)													
2015	5.1	3.4	9.1	2.2	0.5	2.5	1.8	0.5	3.6	0.4	1.9	1.1	**32**
2020	4.7	3.1	9.7	2.5	0.5	2.4	1.9	0.5	3.6	0.4	2.0	1.1	**32**
2025	4.2	2.8	8.5	2.2	0.4	2.2	1.7	0.4	3.2	0.4	1.8	1.0	**29**
2030	3.7	2.5	4.9	1.2	0.4	1.6	1.0	0.3	2.3	0.3	1.1	0.7	**20**
2035	3.3	2.2	4.0	1.0	0.3	1.4	0.9	0.3	2.0	0.2	0.9	0.6	**17**
2040	3.0	2.0	3.1	0.7	0.3	1.1	0.7	0.2	1.6	0.2	0.7	0.5	**14**

Source: Authors' financial flows model.

Table A2. Emissions pathways under business-as-usual scenario ($GtCO_2$)

	USA	EU-27	China	India	Canada	CIS	Latin America	Rest of Europe	Rest of Asia	Austral-asia	Middle East	Africa	**World**
2015	5.2	3.4	9.1	2.1	0.5	2.5	1.8	0.5	3.8	0.4	1.8	1.1	**32**
2020	5.0	3.4	10.4	2.4	0.6	2.6	1.9	0.5	4.2	0.5	1.8	1.2	**35**
2025	4.9	3.4	11.7	2.7	0.6	2.8	2.0	0.6	4.6	0.5	1.8	1.3	**37**
2030	4.8	3.5	12.9	3.1	0.7	2.9	2.1	0.6	4.9	0.5	1.8	1.4	**39**
2035	4.4	3.4	13.3	3.6	0.7	3.1	2.3	0.7	5.1	0.5	1.9	1.6	**41**
2040	4.1	3.4	13.6	4.1	0.7	3.4	2.4	0.8	5.2	0.6	1.9	1.8	**42**

Source: Authors' financial flows model.

Sensitivity analysis

BHE poverty alleviation case

Billion high emitters with poverty alleviation floor allocation: This allocation uses the same approach as the billion high emitter approach in the main text, with an added floor on individual emissions set at 1 tCO_2/year per person (Chakravarty *et al*., 2009). This floor is designed to protect the lower – and poorer – emitters from the economic effects of reducing emissions under the set targets. It essentially has the effect of increasing the emissions cap for developing countries while lowering the cap further for developed countries.

Adding the poverty alleviation floor of 1 tCO_2/year per person emphasises the baseline results. Figure A1 displays outputs for 20, 25 and 30 Gt global targets.

The poverty alleviation floor has the effect of pushing up both net demand and net supply of allowances in all cases, accentuating the dynamics at play in the billion high emitter allocations. The main dynamics continue to hold, except in the case of a looser global emissions reductions target, where the EU-27 emerges as the largest net seller of allowances. This mirrors results presented in the main text.

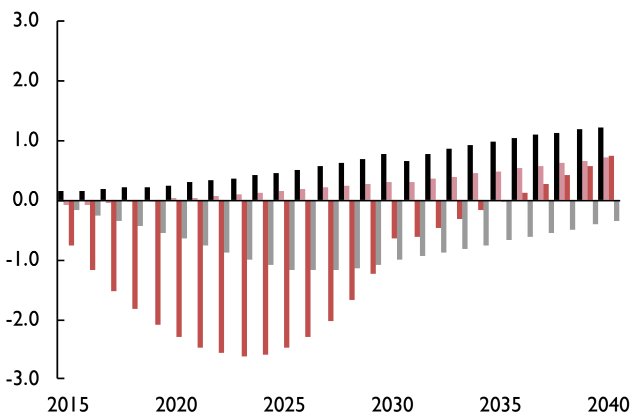
Equal per capita 2030 population case

As in our baseline scenario, the results of an equal per capita allocation scenario, based on 2030 population estimates, show India becoming the largest net seller of permits. However, we also find that in this case China overtakes the United States as the largest buyer of allowances around 2030, thus making China and India polar opposites for the remainder of the decade. A similar dynamic occurs in an equal per capita allocation scenario based on 2010 population numbers, but China does not surpass the United States in its net demand for allowances until close to 2040 (figure A2).

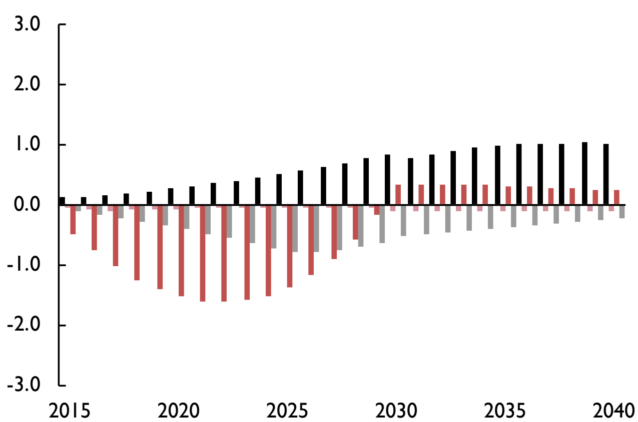
This is an important caveat to our main conclusion as it shows that there is also much at stake for China in the choice of more extreme allocation mechanisms. The results underscore the growing importance of India in climate negotiations but also show that China will continue to be consequential.

Figure A1. Residual demand ($GtCO_2$) for CO_2 permits in the billion high emitters with poverty alleviation allocation

Billion high emitters (20 $GtCO_2$ global target by 2030)



Billion high emitters (25 $GtCO_2$ global target by 2030)



Billion high emitters (30 $GtCO_2$ global target by 2030)

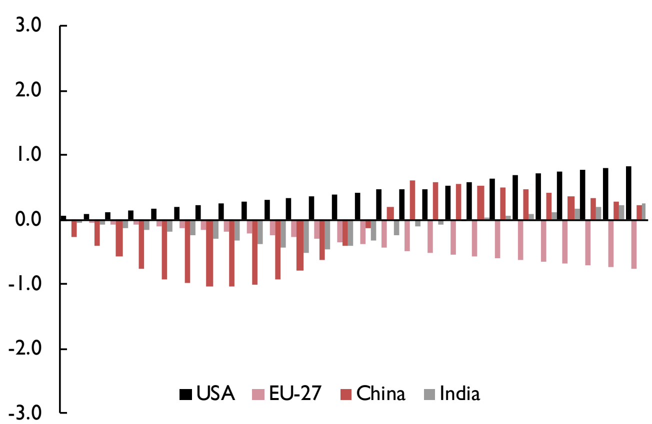
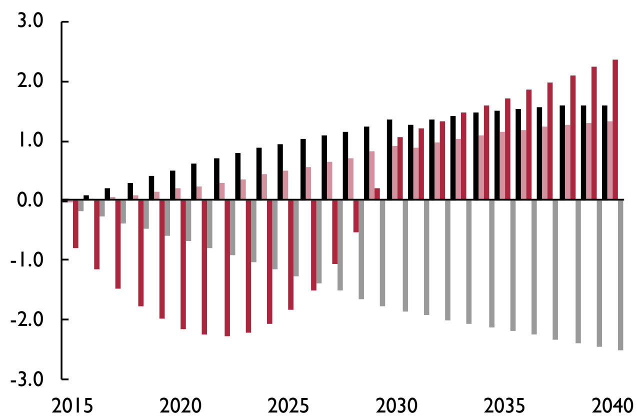
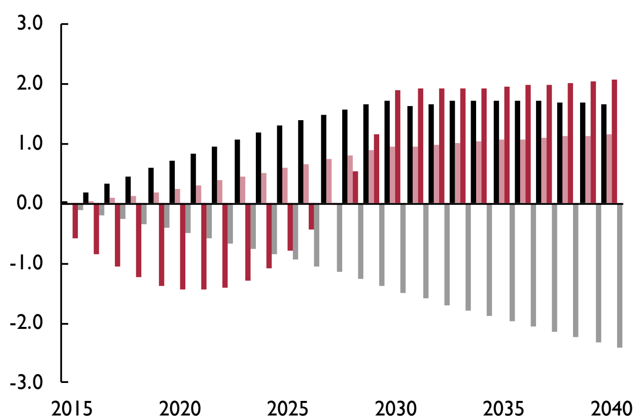


Figure A2. Equal per capita based on population estimates for the year 2030 show China and India as polar opposites as Chinese demand for allowances overtakes the United States by around 2030 ($GtCO_2$)

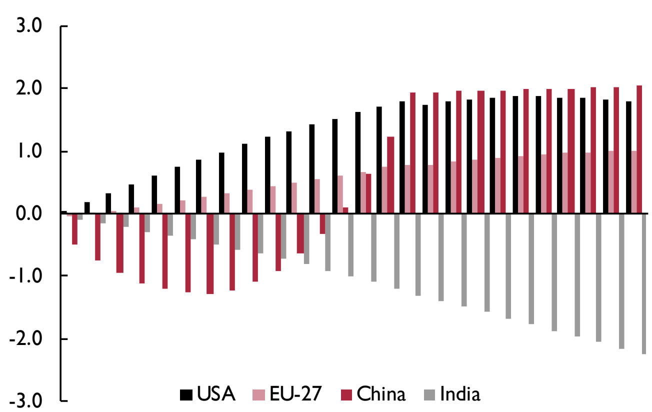
EpC 2030 population (20 $GtCO_2$ global target by 2030)



EpC 2030 population (25 $GtCO_2$ global target by 2030)



EpC 2030 population (30 $GtCO_2$ global target by 2030)



Data sources and calculations

Enerdata's POLES is a world energy model with a year-by-year simulation of energy balances for 45 countries and 12 world regions. It includes business-as-usual projections of CO_2 emissions to 2050, as well as analysis of CO_2 abatement strategies under the form of marginal abatement cost curves. We aggregate country data into 12 geographical units (4 countries and 8 regions), detailed in table A2.

POLES data were adjusted with historical data, up until 2013, from International Energy Agency (2015, 2014). POLES forecasts are available for every fifth year from 2015 to 2050. We linearly interpolated data for years in between.

Allocations and ensuing calculations are described in the main text. As noted, for each scenario, the allocation methodology is applied to an emissions target in year 2030. Emissions pathways from 2015 to 2050 are then determined using curve fitting based on historical data starting in year 2000 (International Energy Agency, 2015), 2014). Curves were fitted using second and third order polynomials, as well as exponential trend lines, depending on the case.

The model itself runs in Excel with the Solver tool, and is available from the authors. Baseline data based on POLES are proprietary (Enerdata, 2016) and may only be shared with special permission from Enerdata.