

**EMF 36**  
**Carbon Pricing after Paris**  
**(CarPri)**

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Overview of Core Scenarios

GTAP Conference 2020

Jan Schneider, University of Oldenburg

# Energy Modeling Forum: Round 36

## ***Coordinators***

- Kiel Institute for the World Economy
  - Prof. Dr. Sonja Peterson
  - Malte Winkler
- University of Oldenburg
  - Prof. Dr. Christoph Böhringer
  - Dr. Jan Schneider

## ***Objectives***

- Medium-term economic assessment of NDC's via systematic cross-comparison of results from internationally established energy-economy models
- Global and regional implications of different “Paris regimes” on welfare, GDP, CO<sub>2</sub> prices
- Household-level incidence under different “Paris regimes”

# Results: Participating Groups/Models

| <b><i>Group</i></b>                         | <b><i>Model/Acronym</i></b> |
|---------------------------------------------|-----------------------------|
| Statistics Norway                           | SNoW                        |
| COPPE UFRJ                                  | TEA                         |
| Environment Canada                          | EC-MSMR                     |
| Institut für Weltwirtschaft                 | DART Kiel                   |
| University of Oldenburg                     | UOL                         |
| University of Purdue                        | Purdue                      |
| ETH Zürich                                  | CEPE                        |
| CMCC                                        | CMCC                        |
| University of Graz                          | WEGDYN                      |
| Environmental Defense Fund                  | EDF                         |
| Environment Kyoto                           | Kyoto                       |
| Joint Research Center                       | JRC                         |
| University of Tsinghua                      | Tsinghua                    |
| University of Fudan                         | Fudan                       |
| Technical University of Berlin              | TUB                         |
| Centre for European Economic Research (ZEW) | ZEW                         |
| Basque Centre for Climate Change            | BC3                         |
| Massachusetts Institute of Technology (MIT) | MIT                         |
| Institute of Economic Growth (IEG)          | IEG                         |

# Study Design: Regions and Sectors

|     |                           |     |                          |
|-----|---------------------------|-----|--------------------------|
| USA | United States             | CRU | Crude oil                |
| CAN | Canada                    | COL | Coal                     |
| JPN | Japan                     | OIL | Refined petroleum        |
| KOR | South Korea               | GAS | Natural gas              |
| RUS | Russia                    | ELE | Electricity              |
| CHN | China                     | EIT | Energy intensive goods   |
| IND | India                     | TRN | Transport aggregate      |
| ANZ | Australia and New Zealand | AGR | Agriculture              |
| BRA | Brazil                    | MFR | Other manufactured goods |
| EUR | Europe                    | SER | Services                 |
| MEA | Middle East               |     |                          |
| AFR | Africa                    |     |                          |
| OAM | Other Americas            |     |                          |
| OAS | Other Asia                |     |                          |

# Study Design: Core Scenarios

## ***Baseline***

- IEO                      2030 GDP and CO<sub>2</sub> based on the International Energy Outlook (EIA)
- WEO                      2030 GDP and CO<sub>2</sub> based on the World Energy Outlook (IEA)

## ***Reduction ambition***

- NDC                      Unconditional NDCs, lower bounds
- NDC+                      Conditional NDCs, upper bounds
- NDC-2C                      Scaling of NDC+ to reach 2°C path

## ***Degree of international cooperation***

- REF                      Imposition of NDCs
- GLOBAL                      Global trading across all sectors
- PARTIAL                      Global trading only in EITE sectors
- EUR\_CHN                      Club-trading: EU and China link ETS for EITE sectors
- ASIA                      Club-trading: China, Japan, and Korea link ETS for EITE sectors

# Study Design: Core Scenarios

***Dimensionality: 2x3x5 = 30***

***Baseline***

- IEO
- WEO

***Ambition***

- NDC
- NDC+
- NDC-2C

***Cooperation***

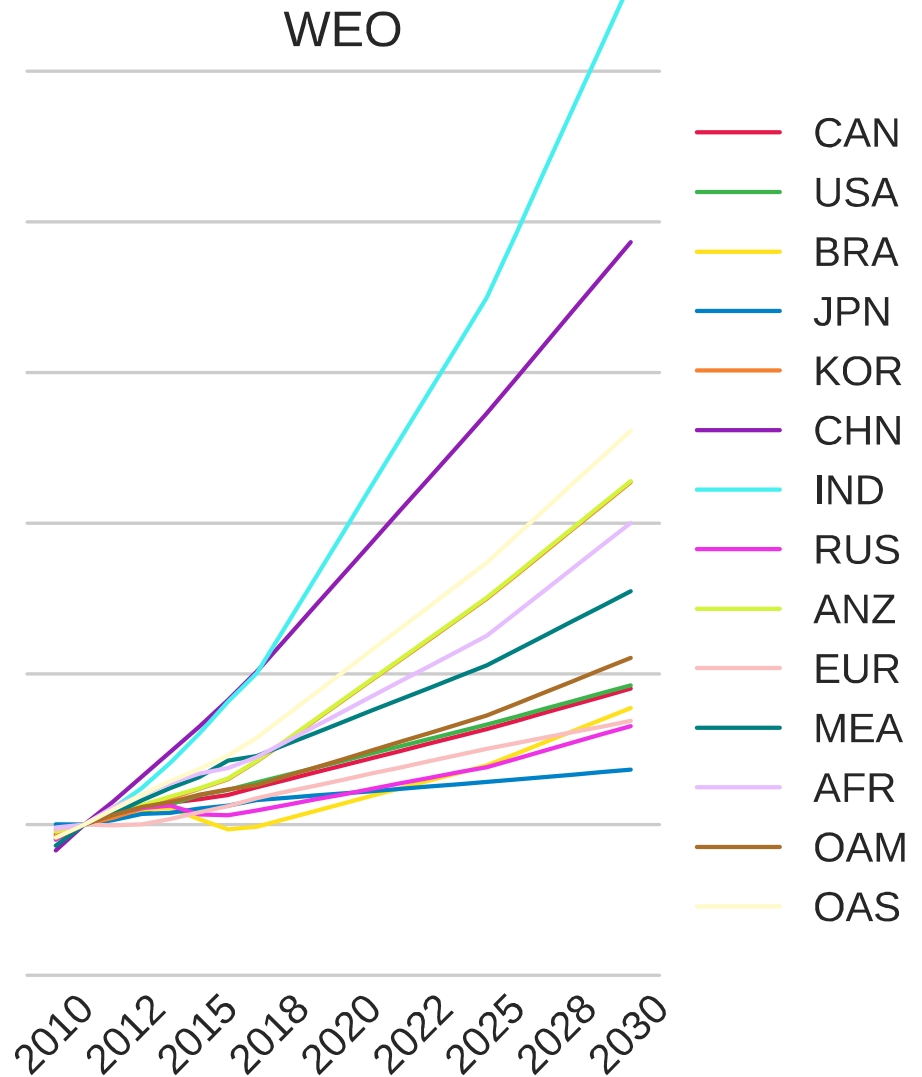
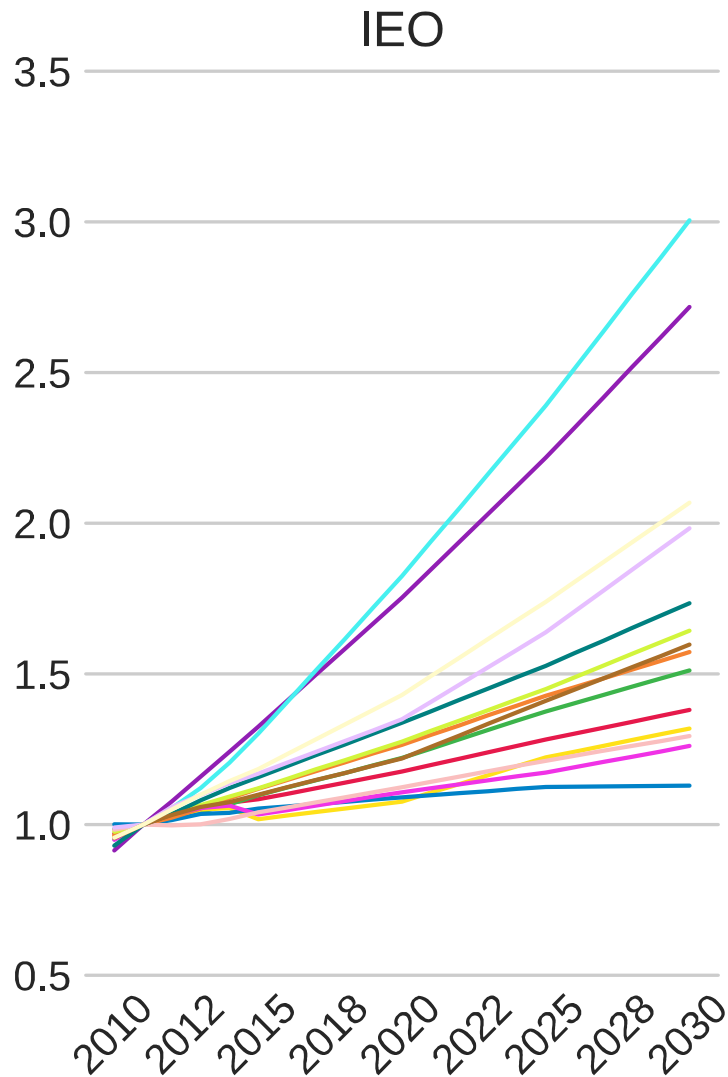
- REF
- GLOBAL
- PARTIAL
- EUR\_CHN
- ASIA

# Foreshadow of “Key” Results

- Efficiency
  - *GLOBAL* scheme cuts global cost by 1/2 to 2/3 compared to *REF*
  - Rather limited global cost savings through EIT where-flexibility only
- Incidence
  - Strong incidence on oil and gas exporters under *REF* – some incidence shifting towards coal under *GLOBAL*
  - South Korea and Europe are the only regions to benefit significantly from EIT trading while China is rather indifferent
- Drivers
  - Direct cost savings through MAC equalization (MAC curves – NDC targets)
  - Terms-of-trade shifts (fuel supply elasticities, Armington trade elasticities)
- Substantial variations across models – EMF value-added

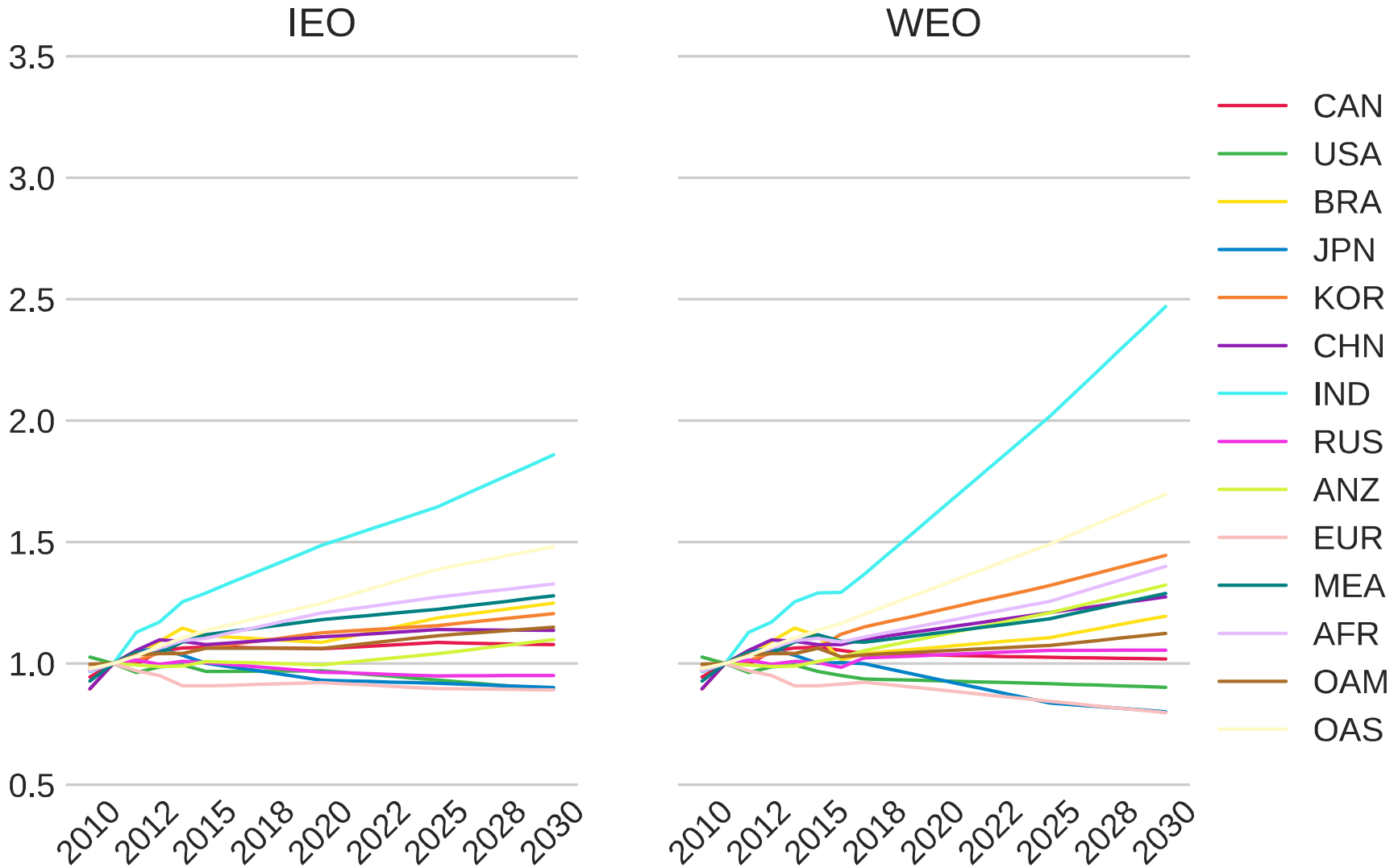
# Baseline Parameters – GDP

(indexed to 2011)

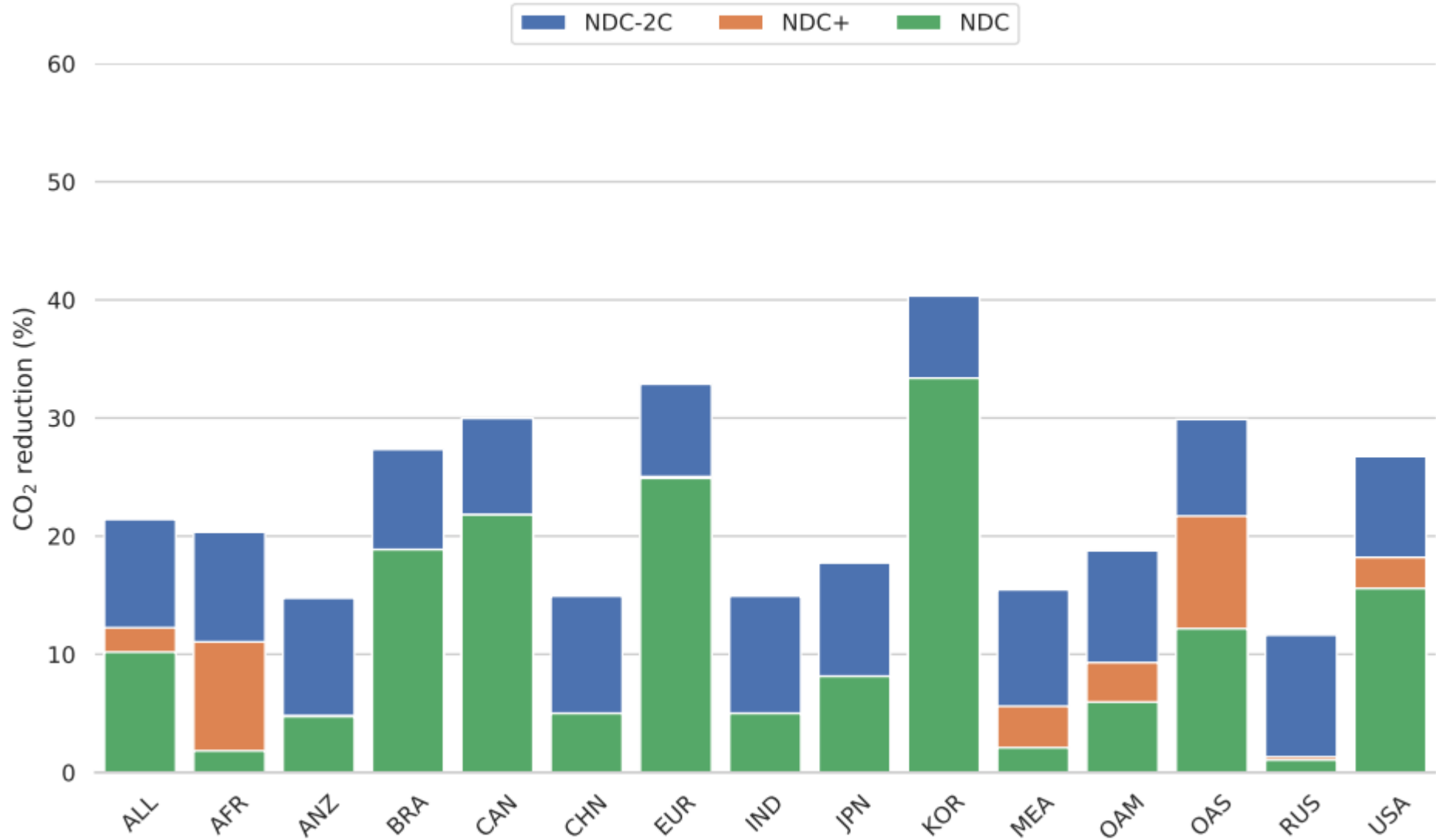


# Baseline Parameters – CO<sub>2</sub>

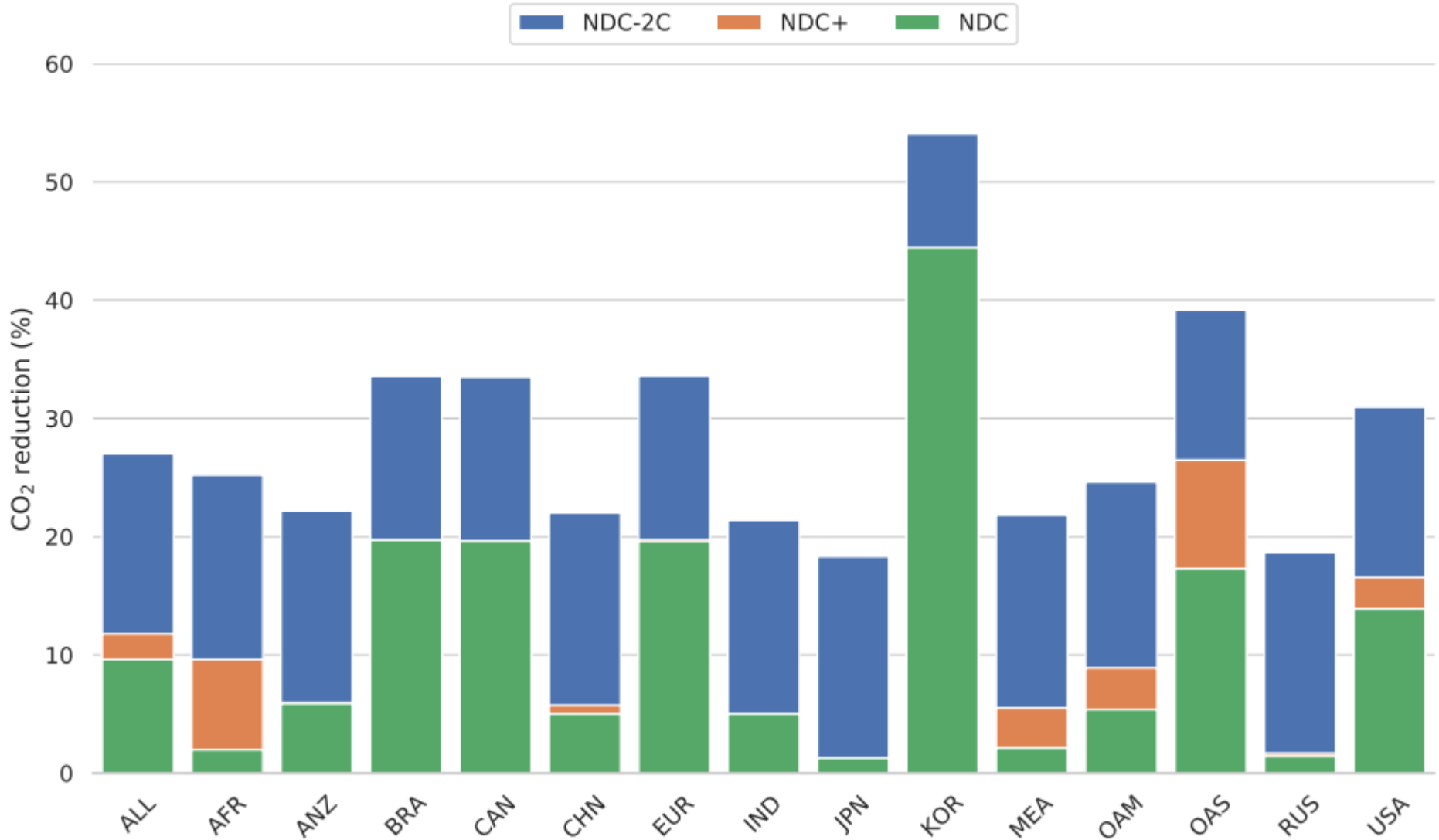
(indexed to 2011)



# Translated NDCs – IEO

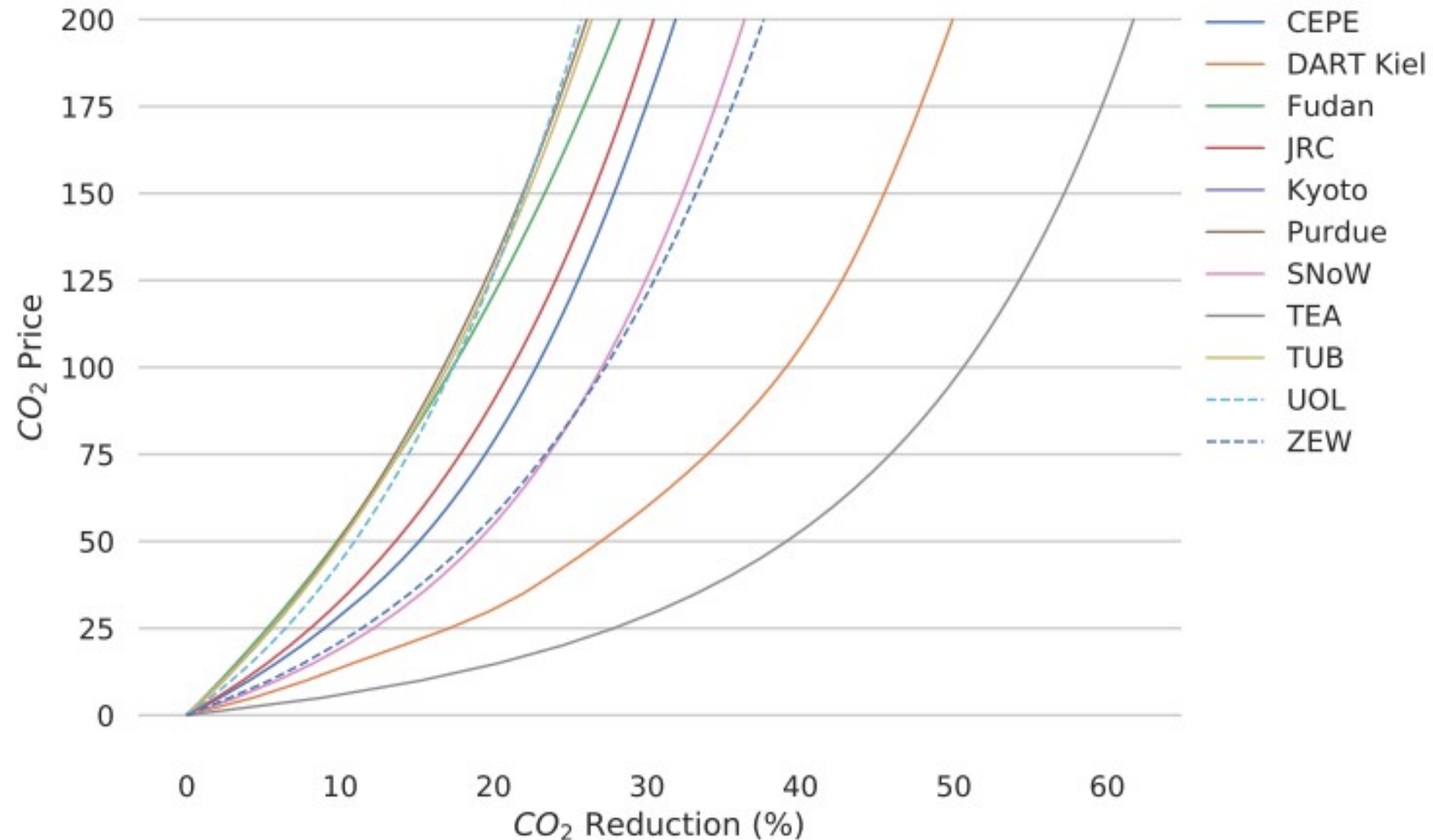


# Translated NDCs – WEO



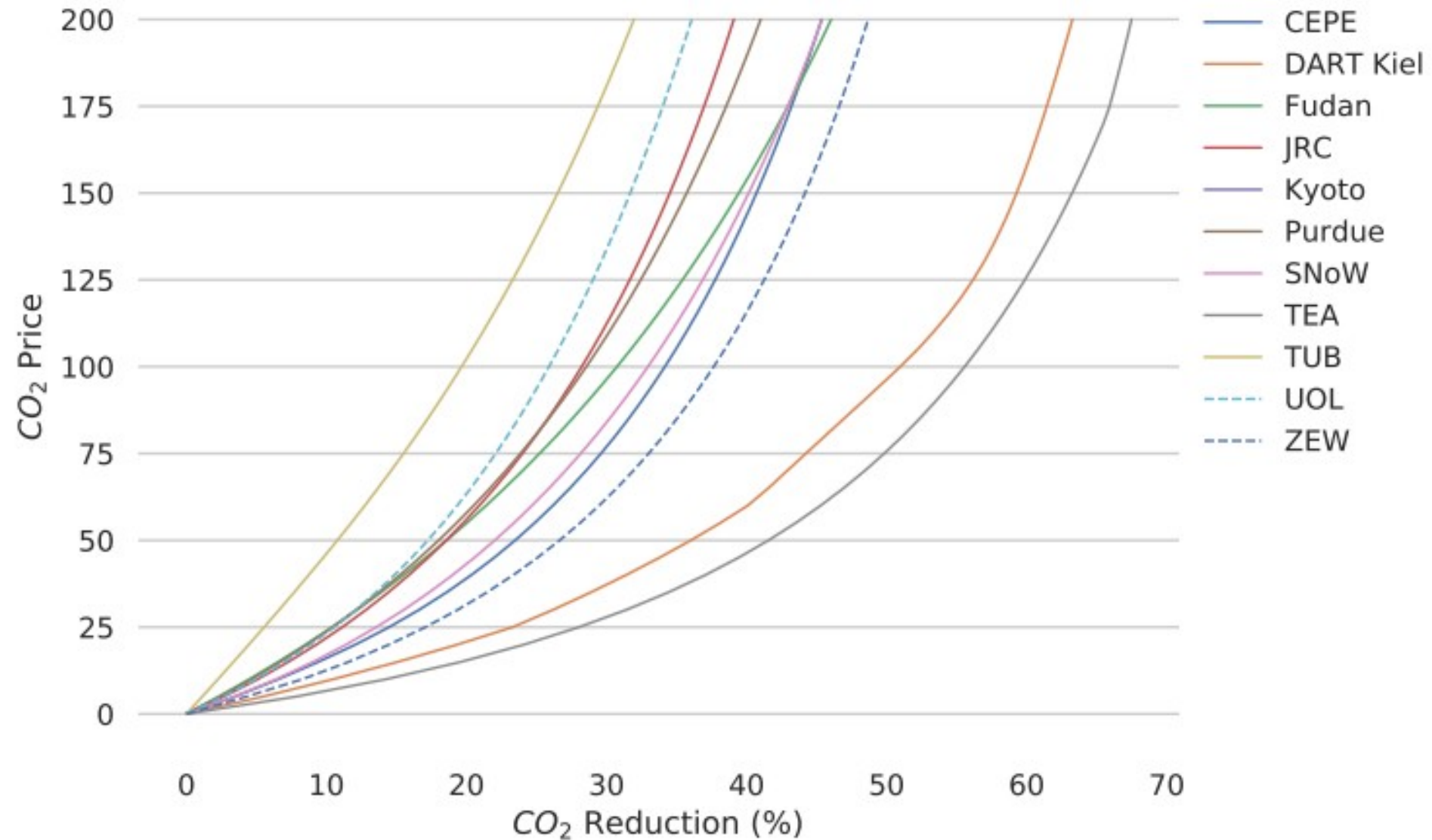
- More emission growth in the WEO baseline → Higher reduction requirements to achieve NDC-2C

# MAC Curves – Europe/EUR (%)

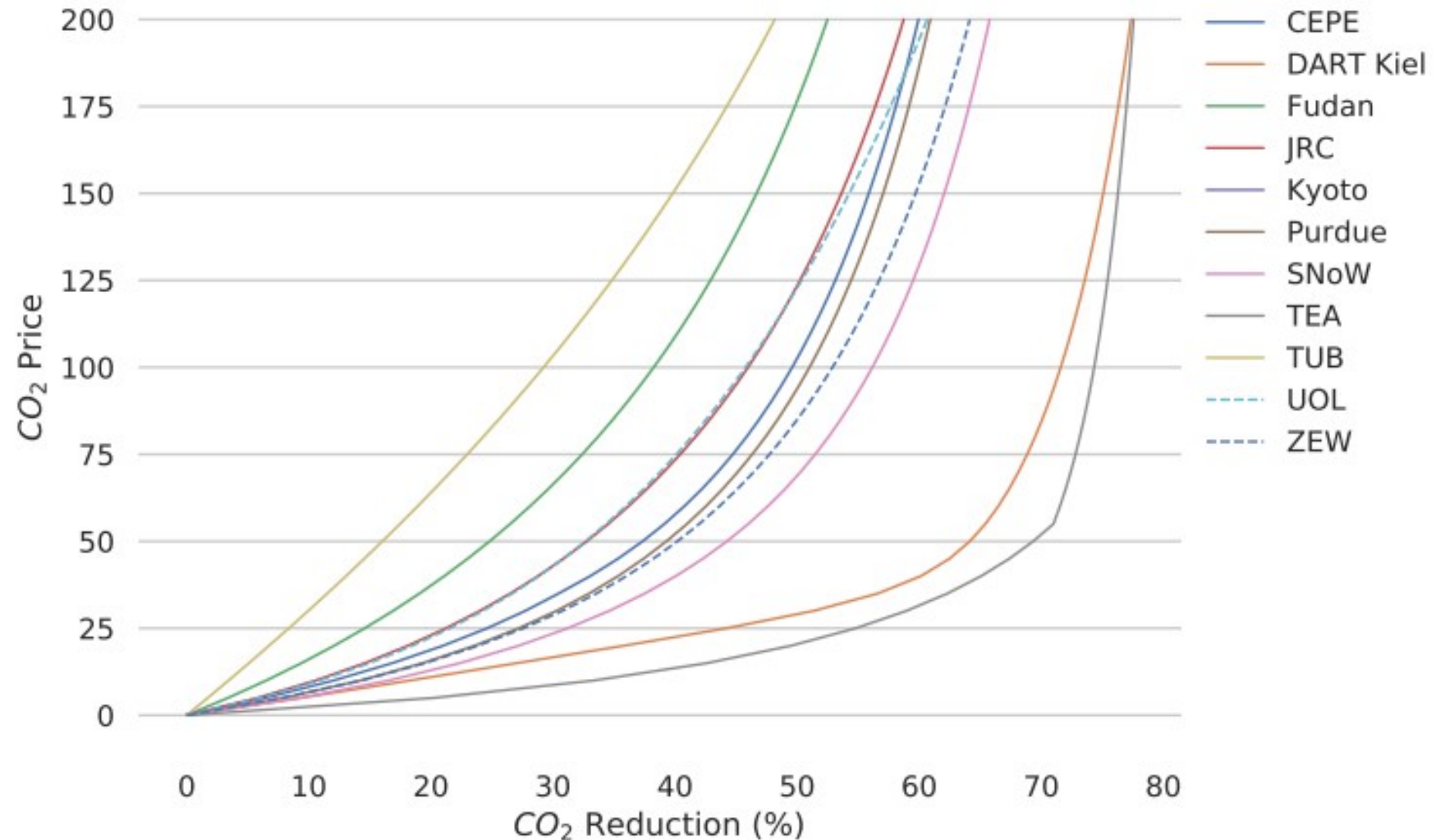


- Main drivers for MAC differences include elasticities (KLEM – interfuel), baseline (explicit and implicit) CO<sub>2</sub> prices, energy prices

# MAC Curves – USA (%)

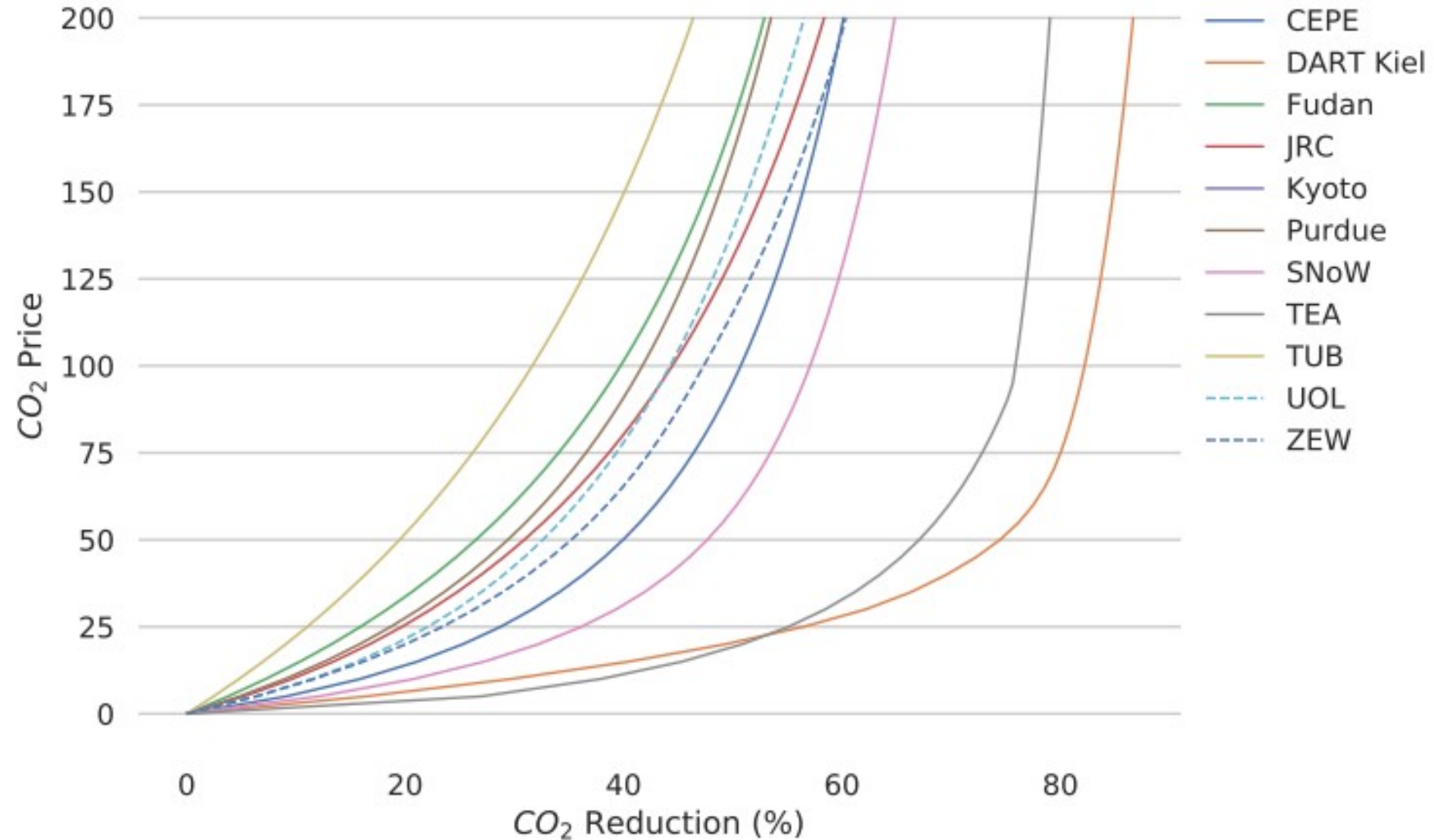


# MAC Curves – China/CHN (%)

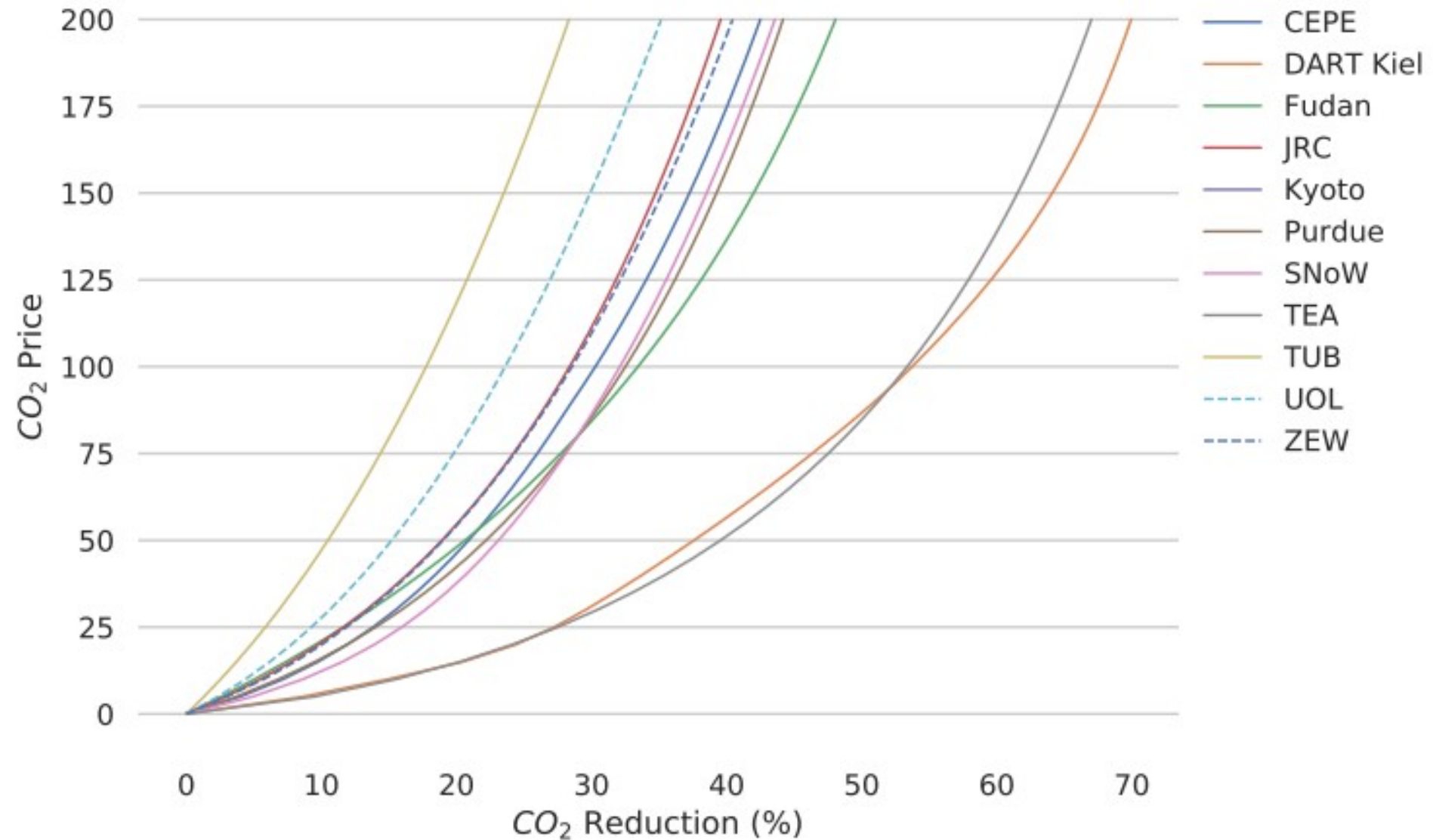


- China and India with substantial amounts of cheap abatement options

# MAC Curves – India/IND (%)



## MAC Curves – Russia/RUS (%)

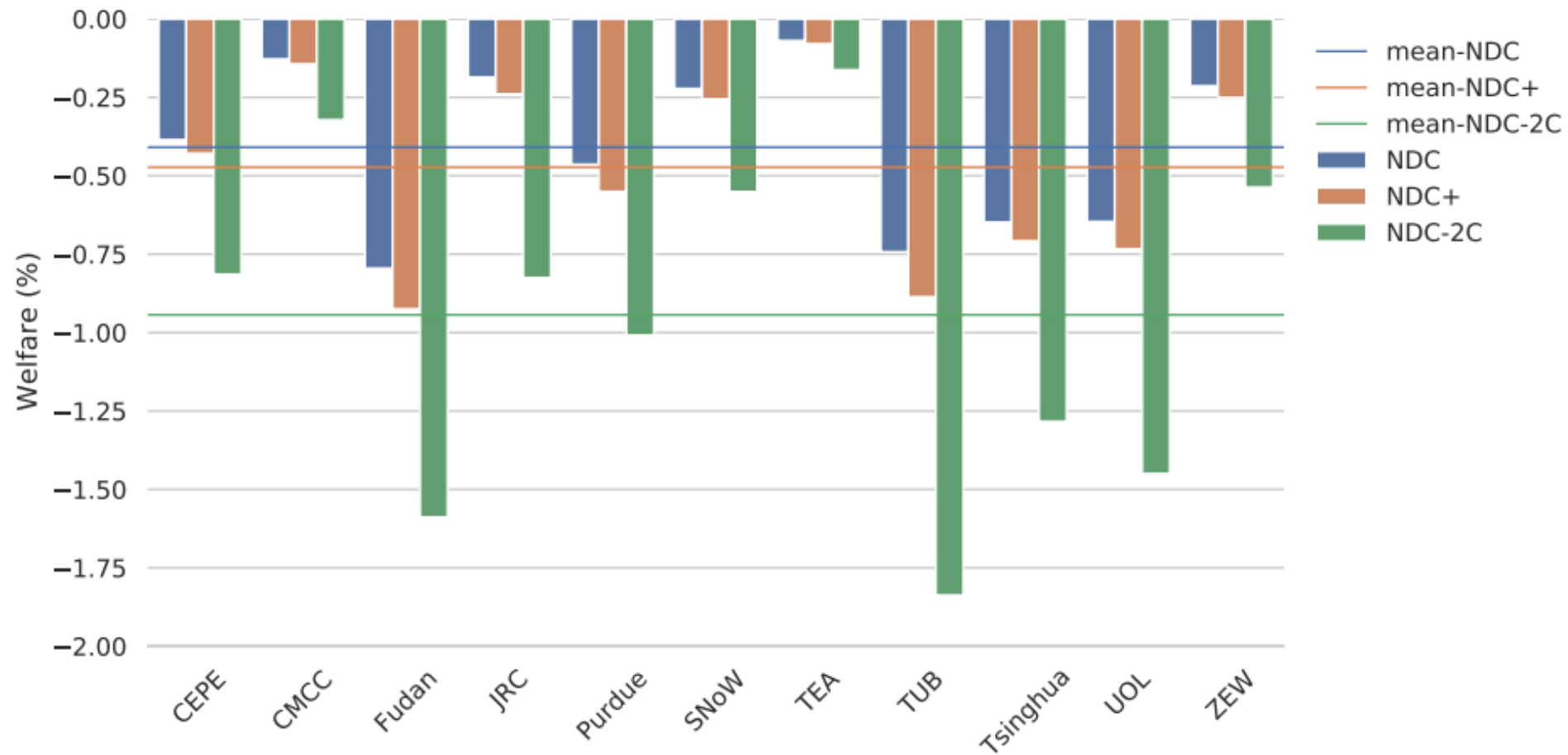


# Core Scenarios Overview

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**Global** welfare, GDP, CO<sub>2</sub> prices  
under *REF* and *GLOBAL*

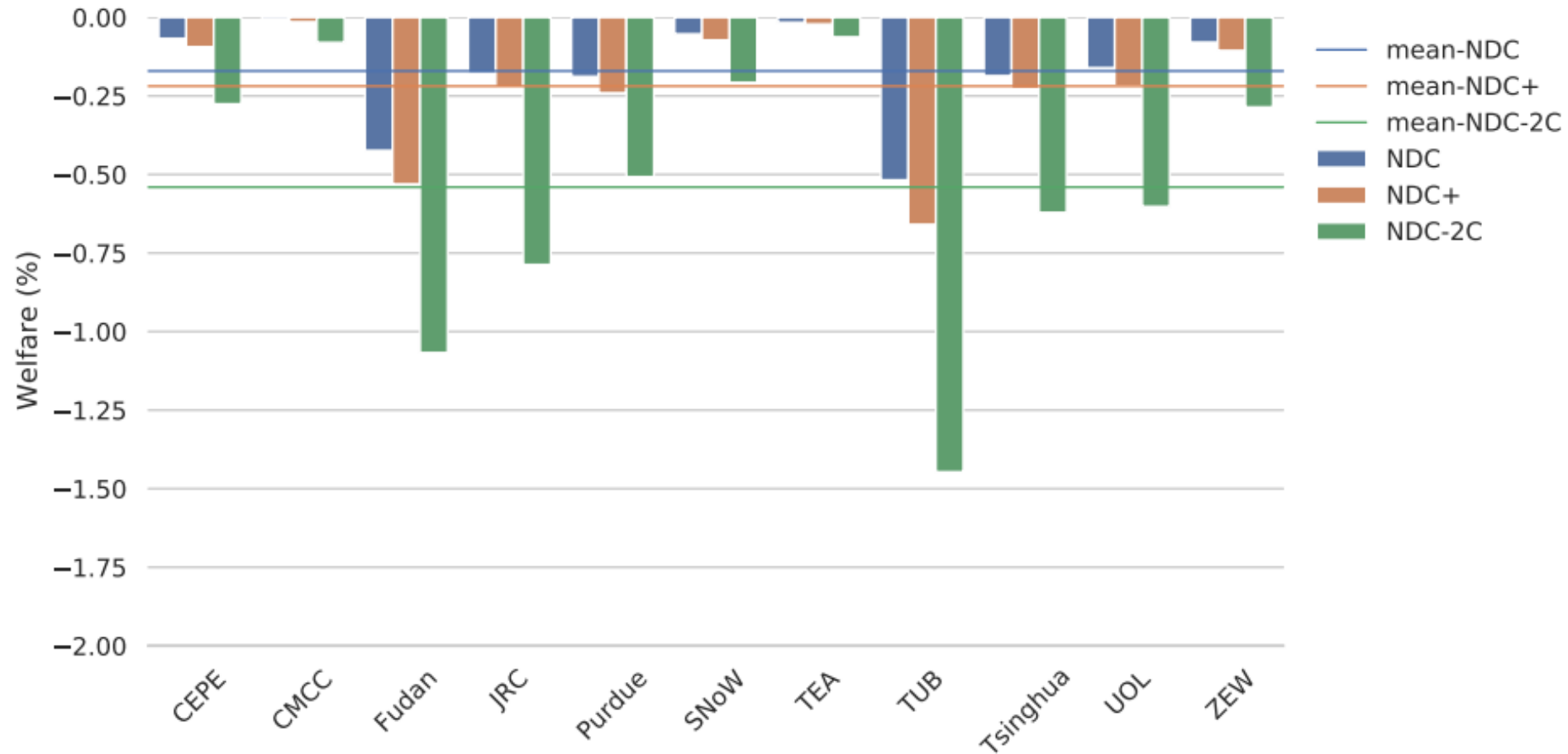
# Global Welfare



- Underlying: MACs
- Marked variation across models
- Rough doubling of cost from NDC/NDC+ to NDC-2C

# Global Welfare

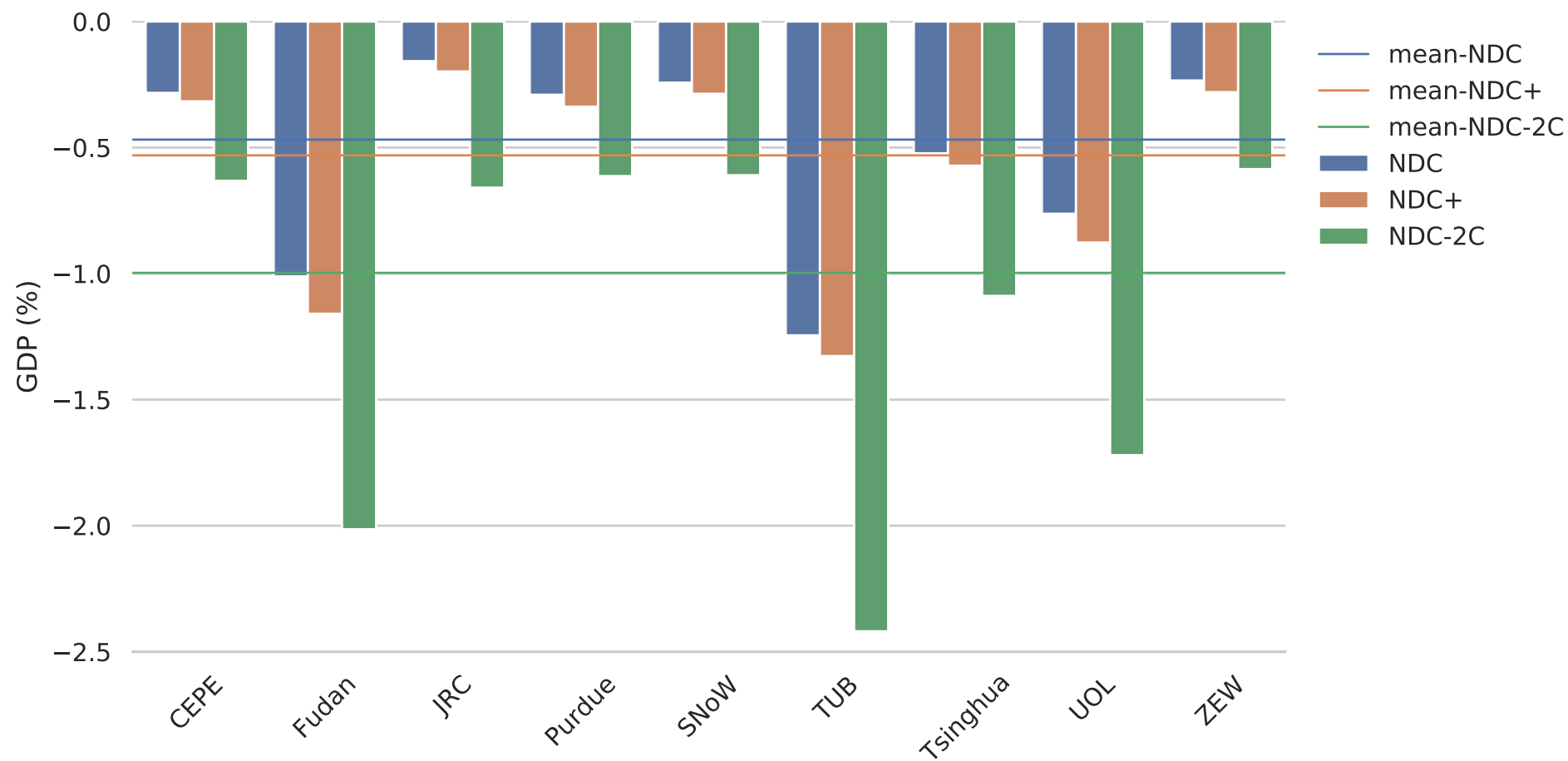
IEO, GLOBAL



- Huge cost savings from global scheme (cut by 1/2 to 2/3)
- Higher relative savings for lower ambition (shape/convexity of MACs)

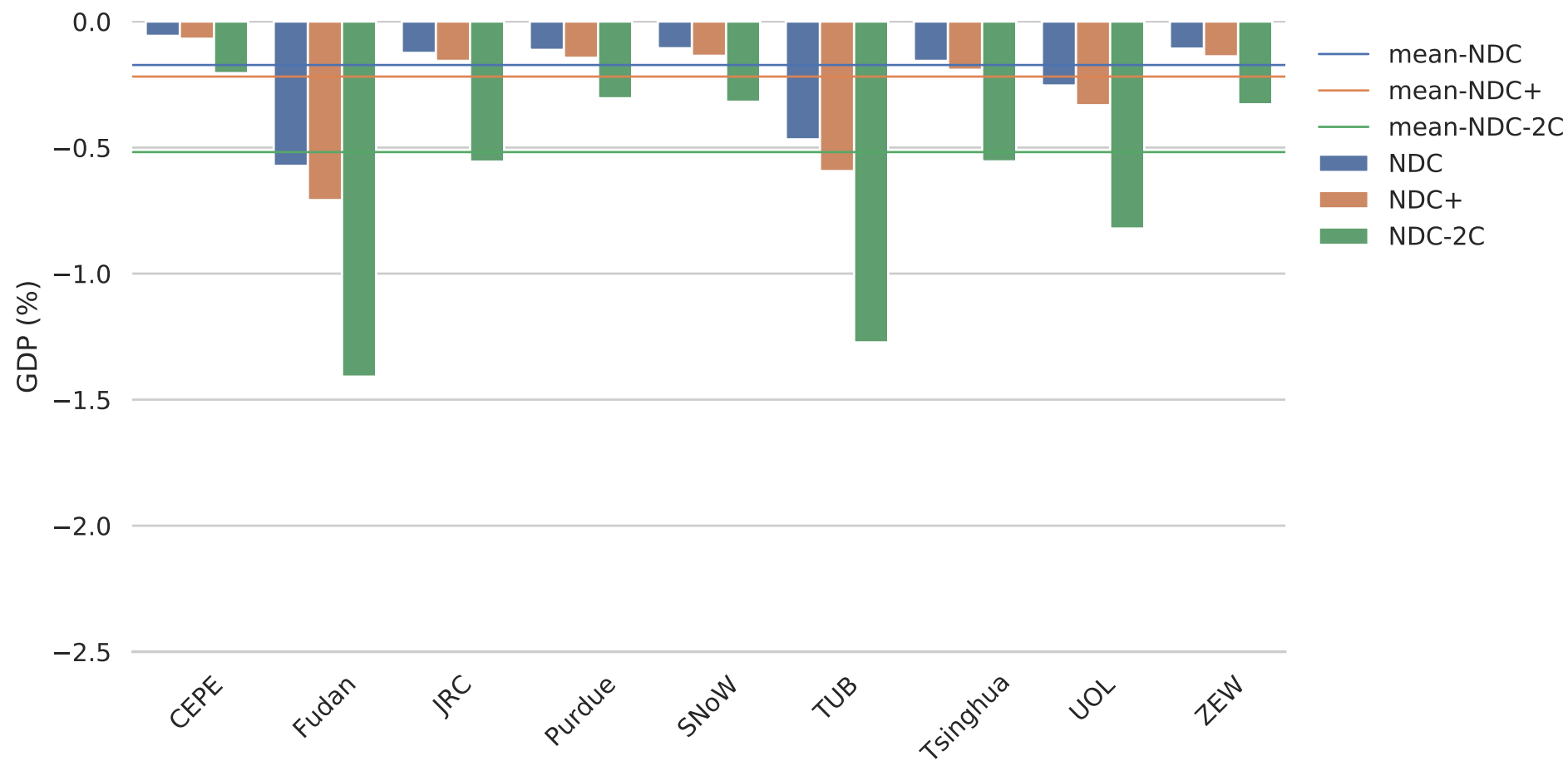
# Global GDP

IEO, REF



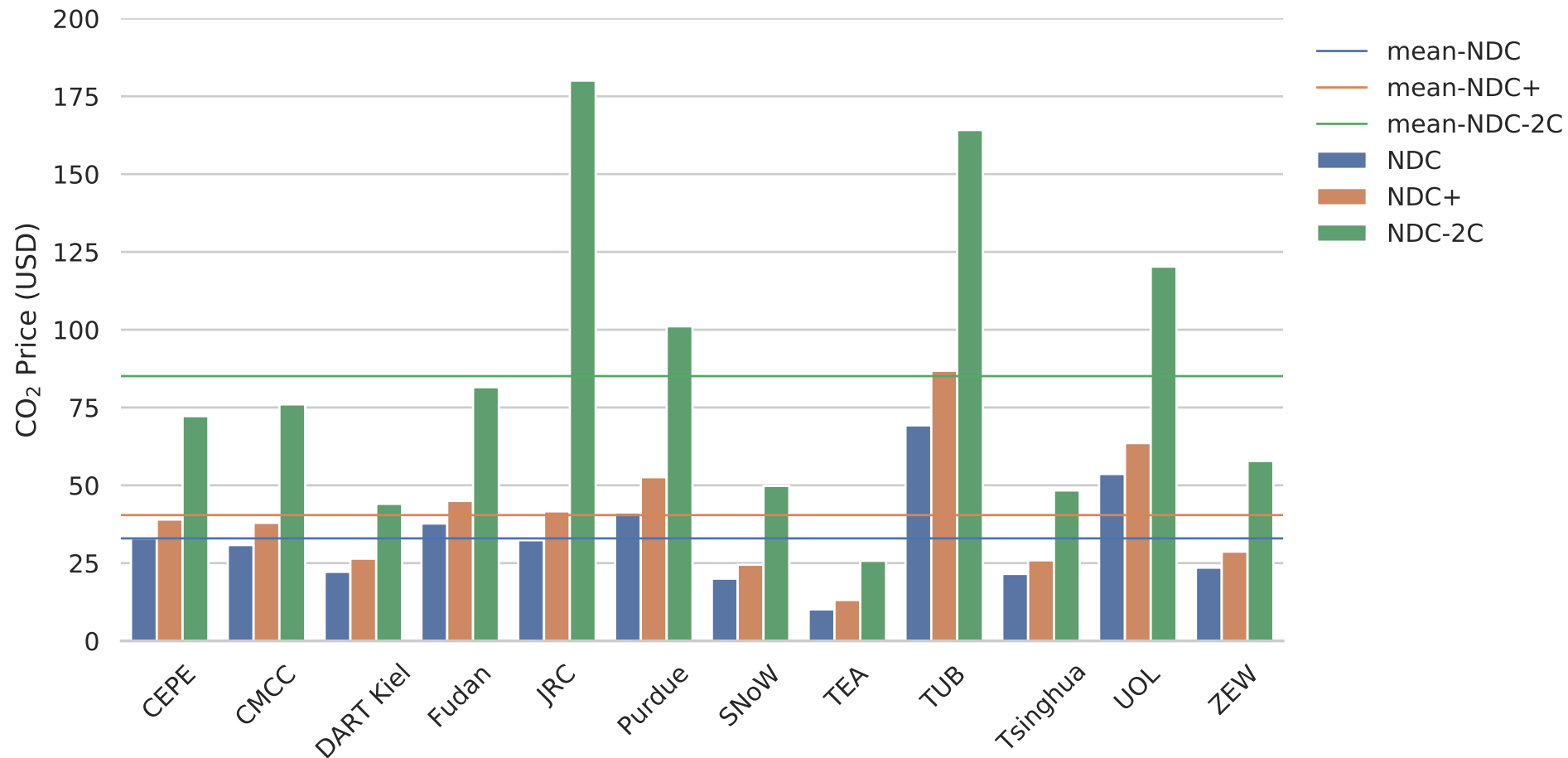
# Global GDP

IEO, GLOBAL



# Global Average CO<sub>2</sub> Price

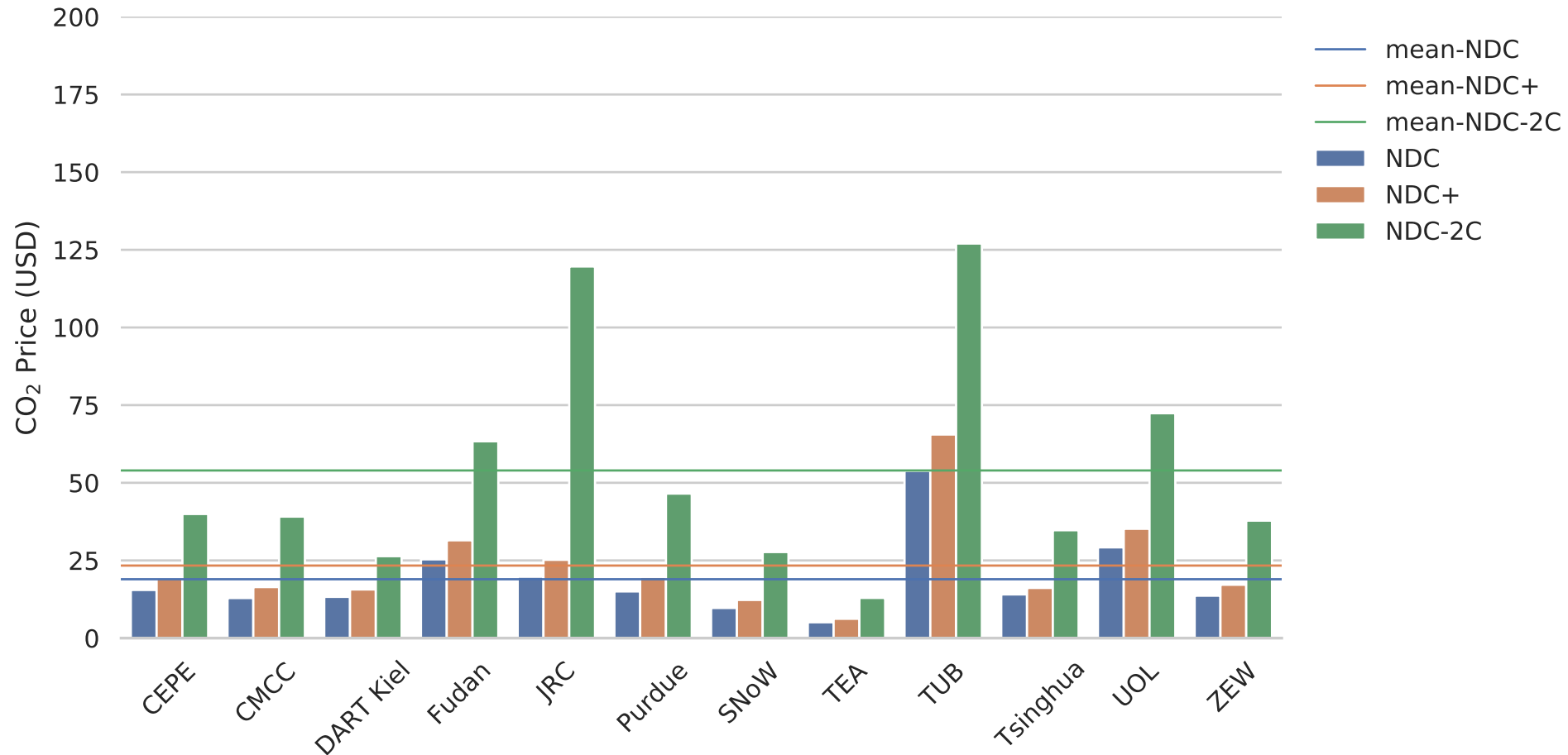
IEO, REF



- Broad range from 10-70 \$/tCO<sub>2</sub> under NDC, 26-180 \$/tCO<sub>2</sub> under NDC-2C
- Underlying: KLEM nesting, elasticities, baseline CO<sub>2</sub> prices

# Global Average CO<sub>2</sub> Price

IEO, GLOBAL



- Global cost savings between scenarios reflected in cross-region differences of CO<sub>2</sub> prices and abatement potential

### ***Baseline***

- IEO
- WEO

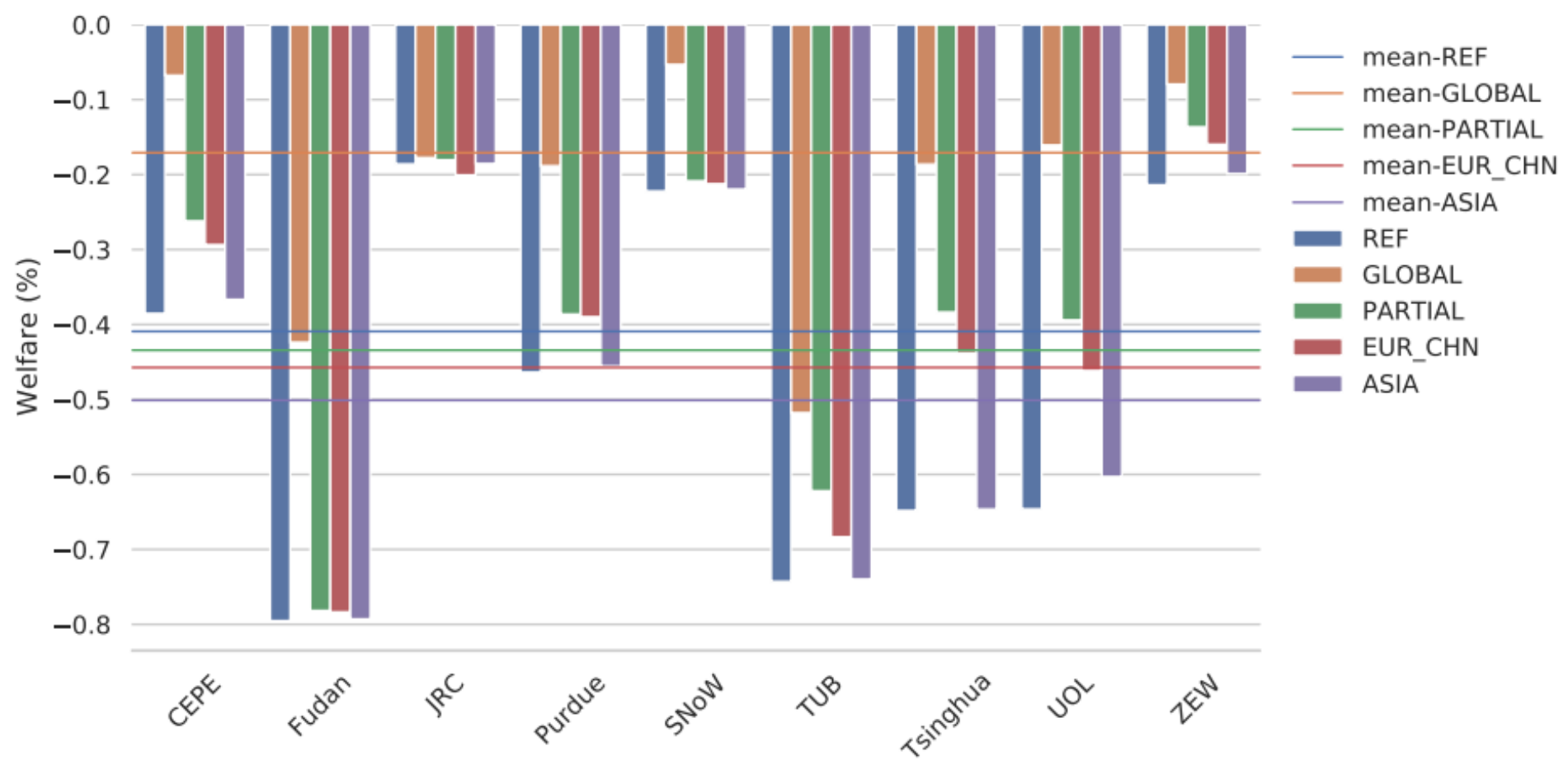
### ***Ambition***

- NDC
- NDC+
- NDC-2C

### ***Cooperation***

- REF
- GLOBAL
- PARTIAL
- EUR\_CHN
- ASIA

# Global Welfare



Thank You!

# APPENDIX

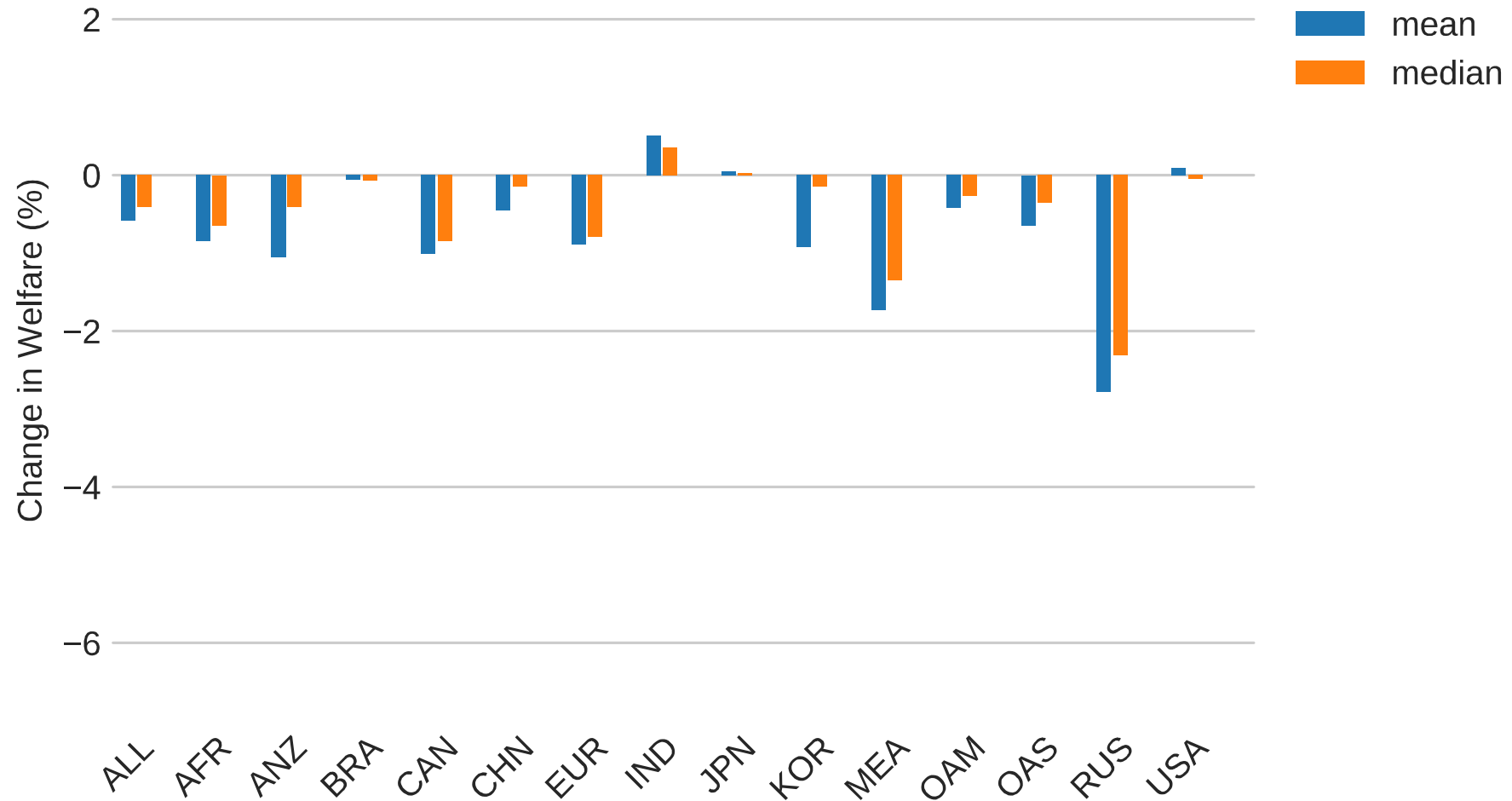
—

More detailed (regional) comparison  
along scenario dimensions

| <i>Baseline</i> | <i>Ambition</i> | <i>Cooperation</i> |
|-----------------|-----------------|--------------------|
| - IEO           | - NDC           | - REF              |
| - WEO           | - NDC+          | - GLOBAL           |
|                 | - NDC-2C        | - PARTIAL          |
|                 |                 | - EUR_CHN          |
|                 |                 | - ASIA             |

# Regional Welfare

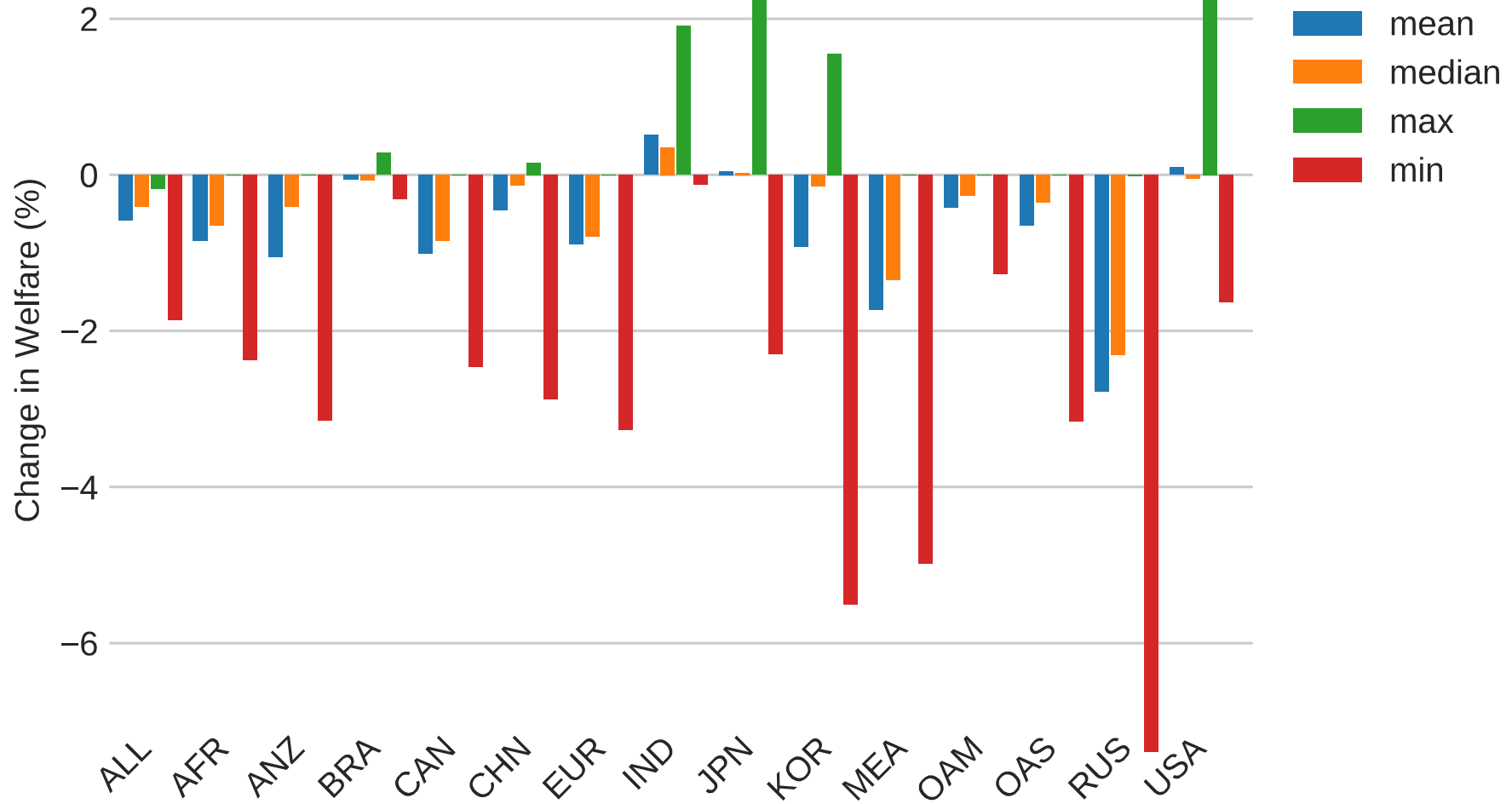
IEO, NDC, REF



- IND: relatively low reduction target compared to other emitters
- MEA and RUS: decline in CRU (OIL) and GAS prices (importance of fuel supply elasticities for CRU, GAS, and COAL)

# Regional Welfare

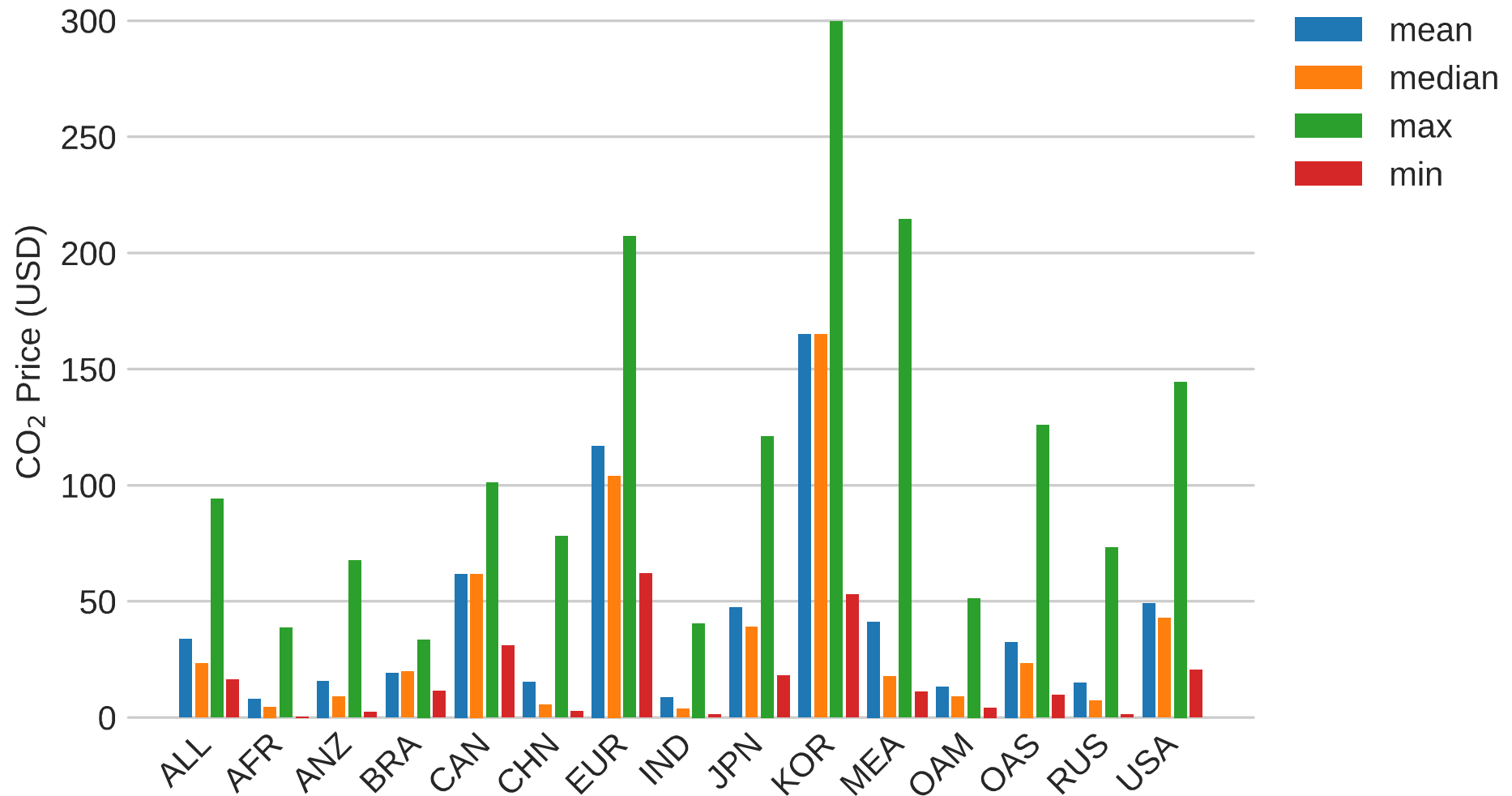
IEO, NDC, REF



- MACs and ToT changes as key welfare drivers

# Regional CO<sub>2</sub> Prices

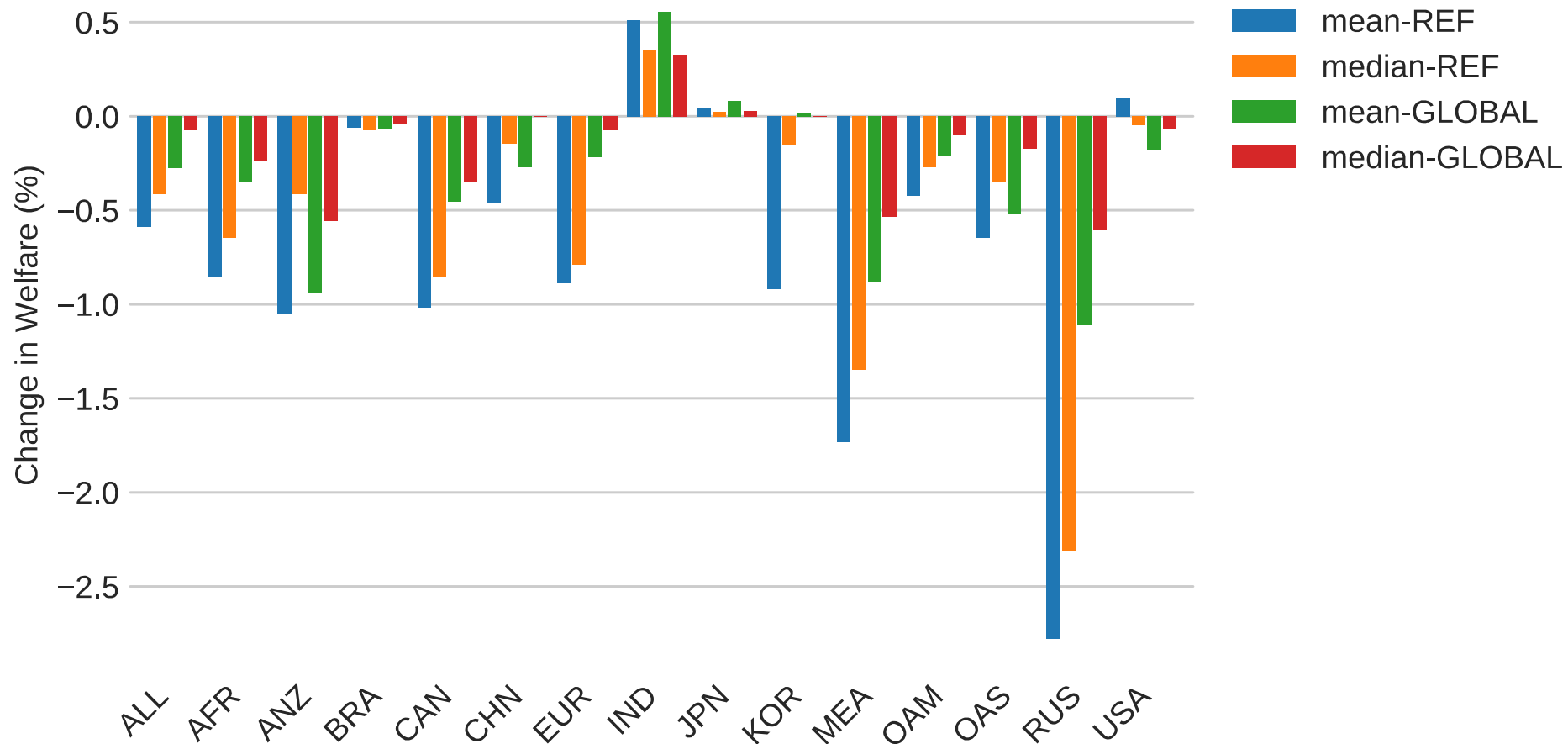
IEO, NDC, REF



Dito

# Regional Welfare – REF, GLOBAL

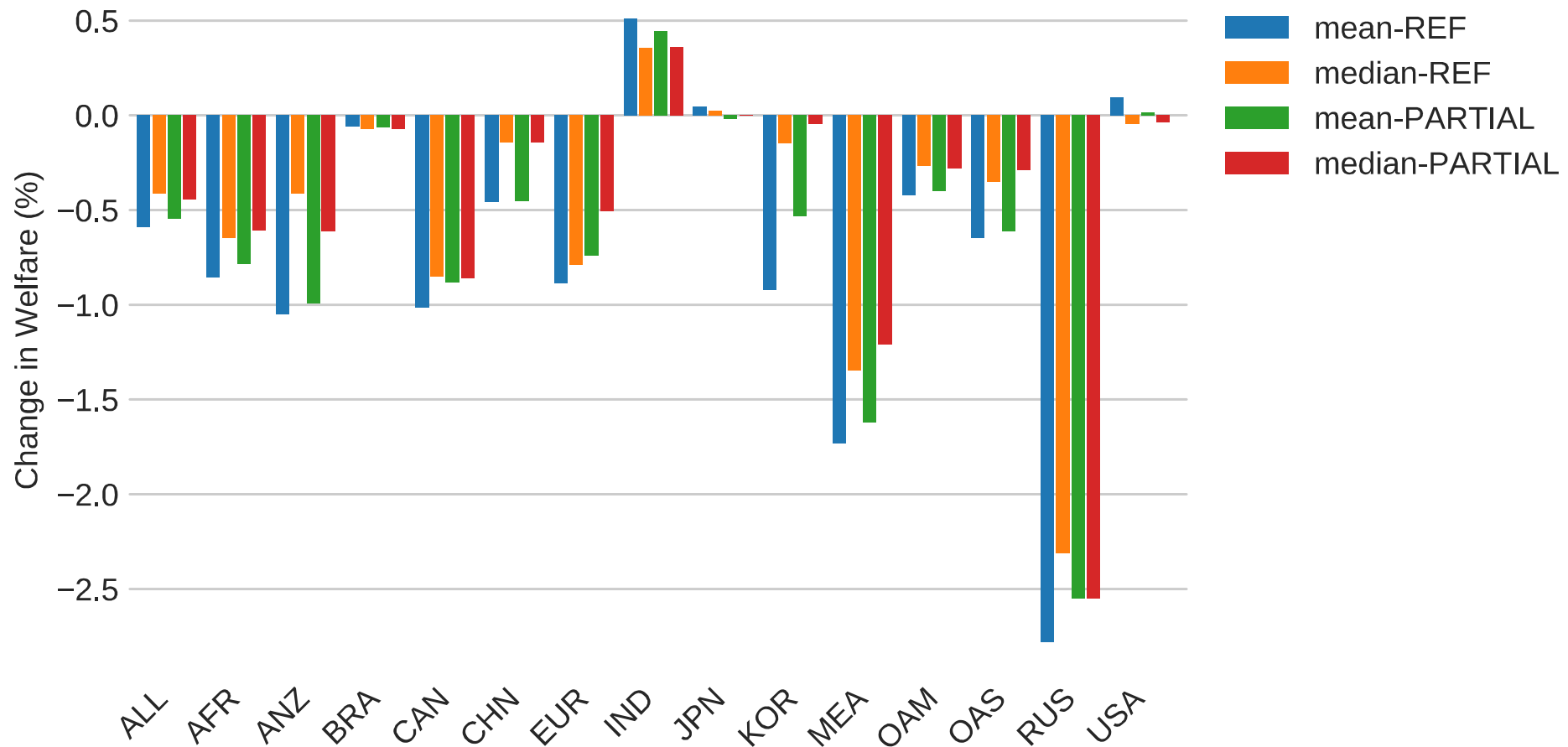
IEO, NDC



- Unambiguous: Welfare gains on CO<sub>2</sub> market (CO<sub>2</sub> prices and abatement potential; MACs)
- Ambiguous: ToT on fuel markets (incidence shift from OIL, GAS to COAL) and non-fuel markets

# Regional Welfare – REF, PARTIAL

IEO, NDC

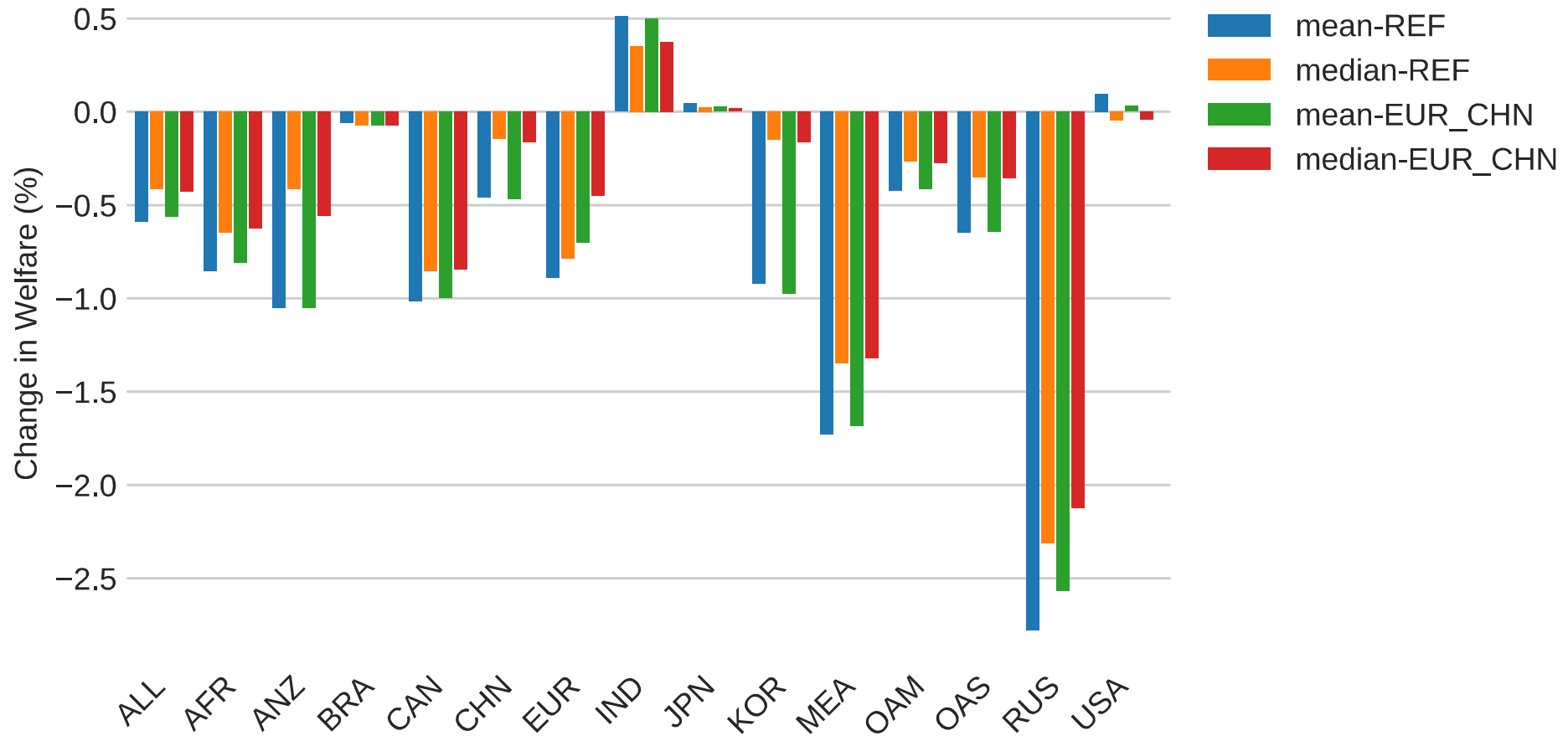


- KOR and EUR are the only regions that benefit significantly
- No incidence shift from OIL/GAS to COAL

Dito

# Regional Welfare – REF, EUR\_CHN

IEO, NDC

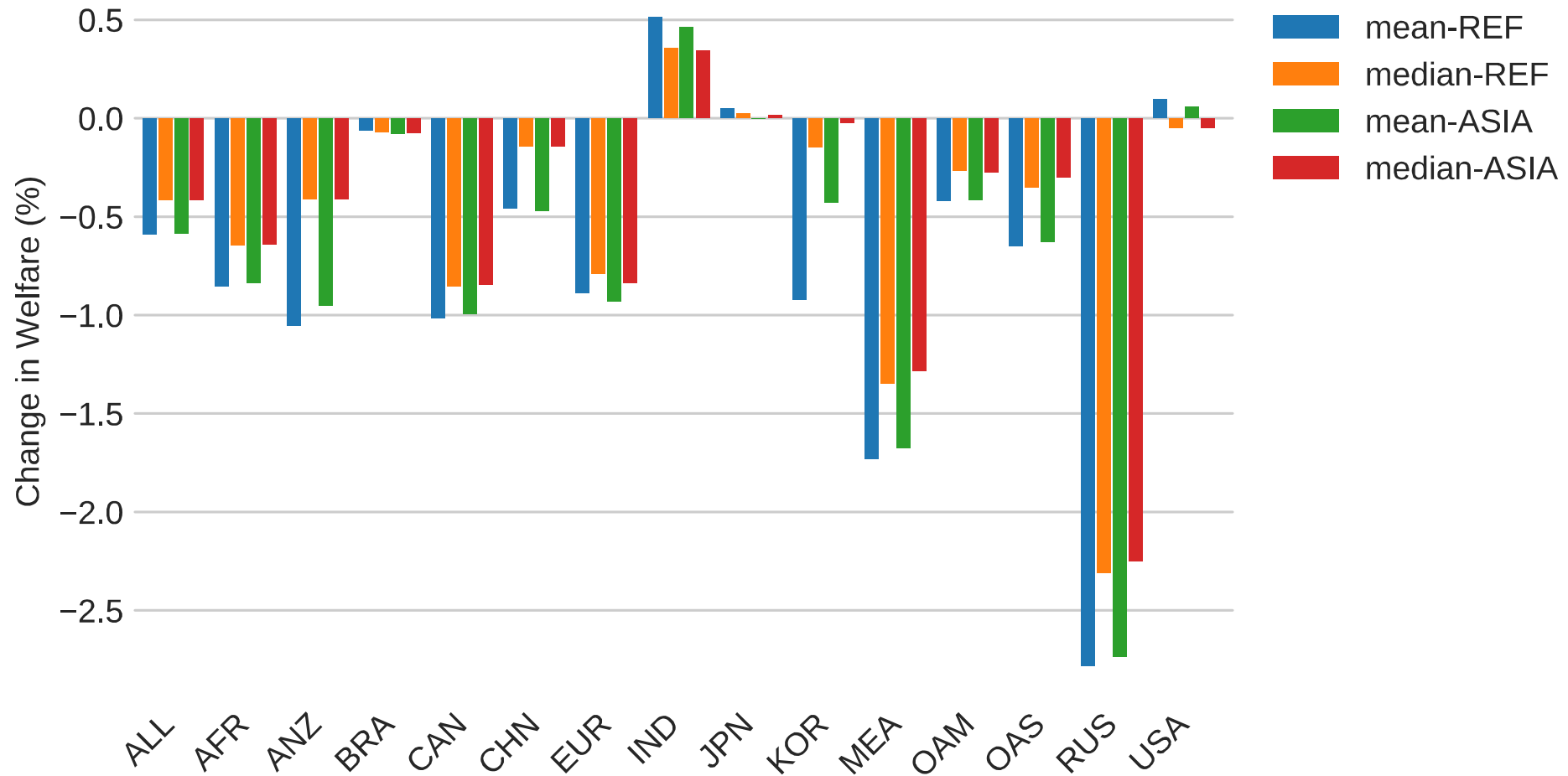


- Slightly worse for CHN (trade is not always beneficial – ToT)
- Slightly better than PARTIAL for EUR (ToT)

Dito

# Regional Welfare – REF, ASIA

IEO, NDC

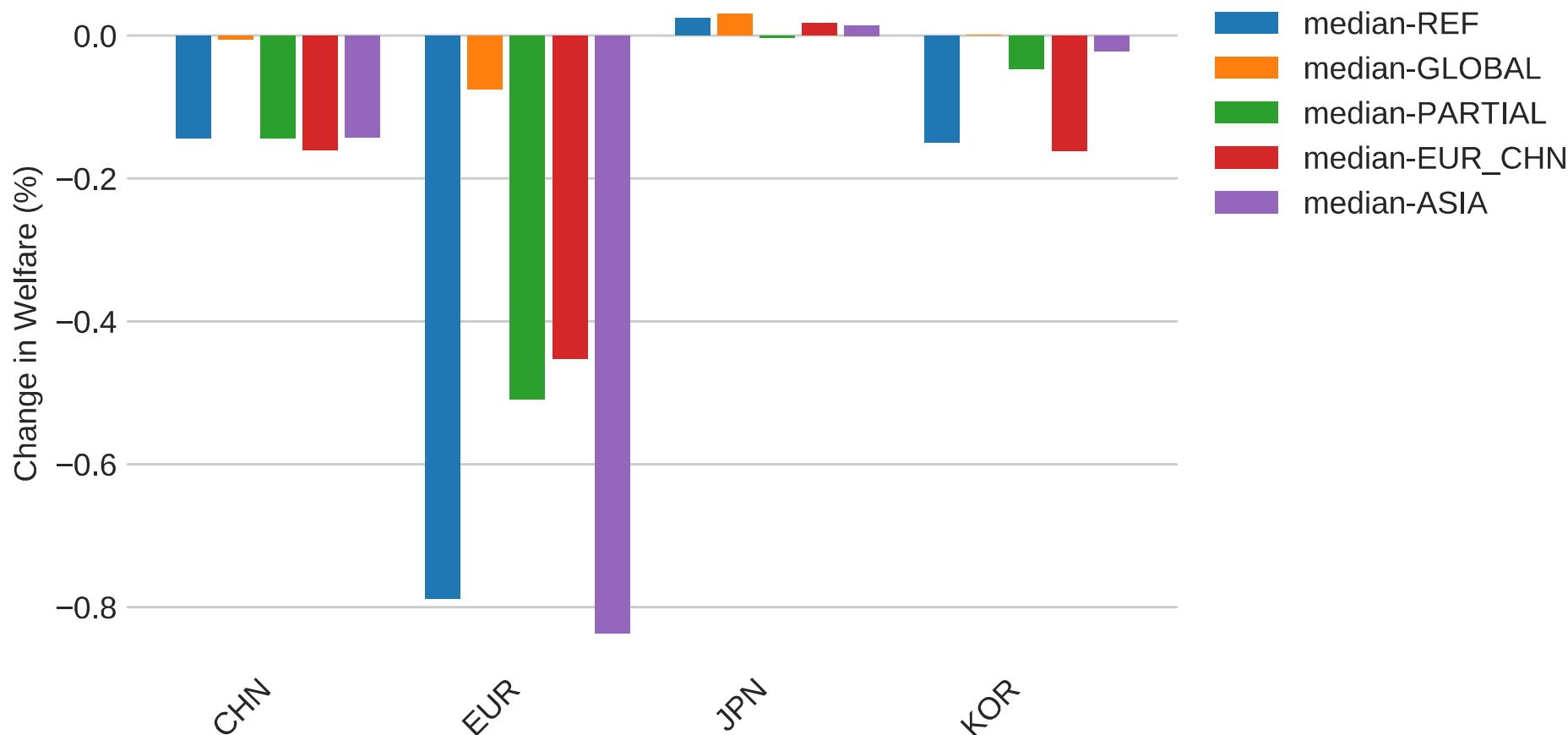


- Again: Negligible changes for CHN
- Again: KOR benefits from EIT trading

Dito

# Regional Welfare – “Clubbers”

IEO, NDC



- CHN rather indifferent about EIT trading (direct gains from CO<sub>2</sub> trade are offset through indirect ToT losses)
- CHN’s trading partners slightly lose when not in the club: EUR under ASIA, KOR under EUR\_CHN

Dito

***Baseline***

- IEO
- WEO

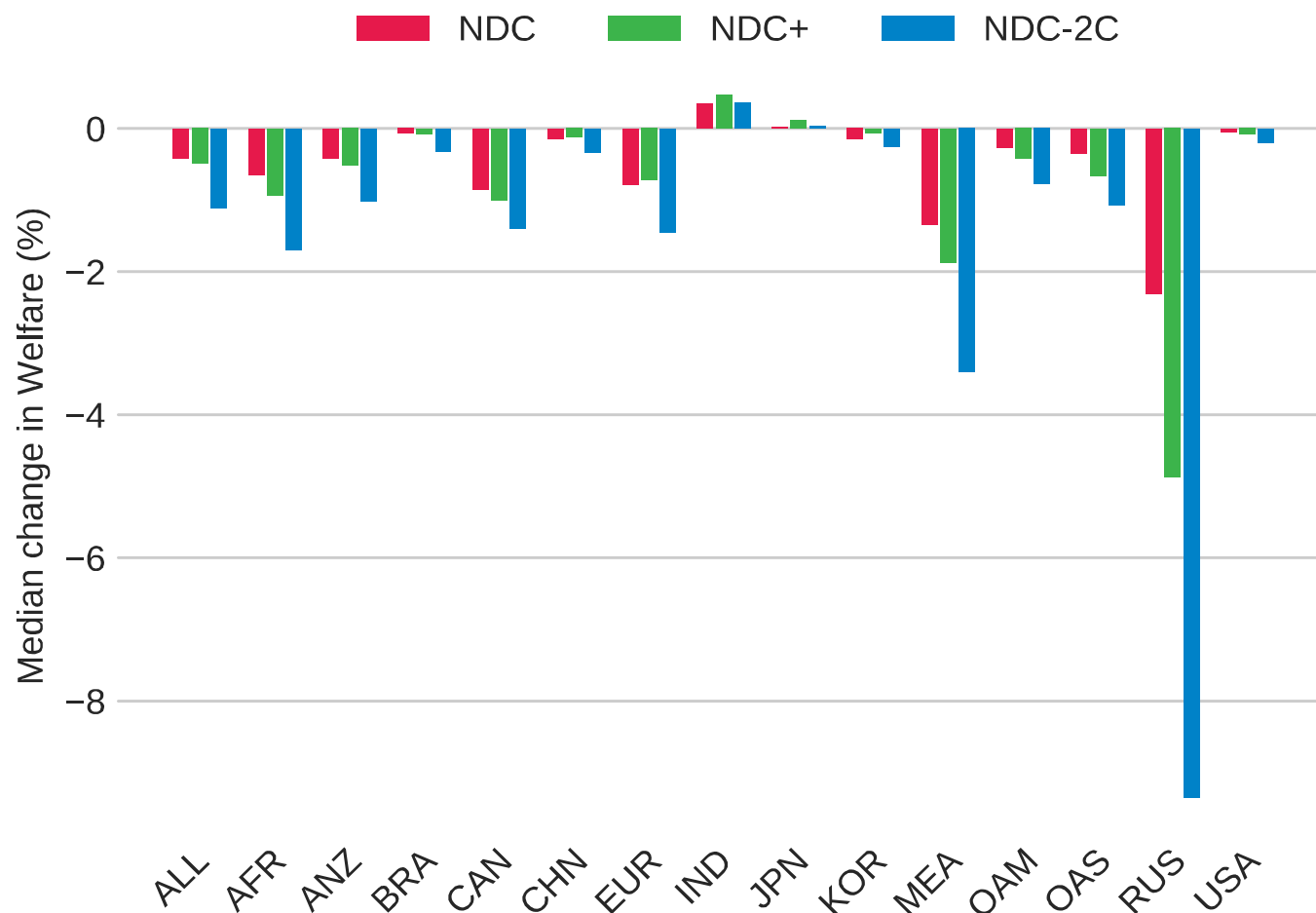
***Ambition***

- NDC
- NDC+
- NDC-2C

***Cooperation***

- REF
- GLOBAL
- PARTIAL
- EUR\_CHN
- ASIA

# Regional Welfare



- NDC+: Stronger incidence on regions with conditional targets (RUS,...), and slightly lower incidence on regions without conditional targets (EUR, JPN)
- NDC-2C: Highest cost for all regions (except for India)

Dito

### ***Baseline***

- IEO
- WEO

### ***Ambition***

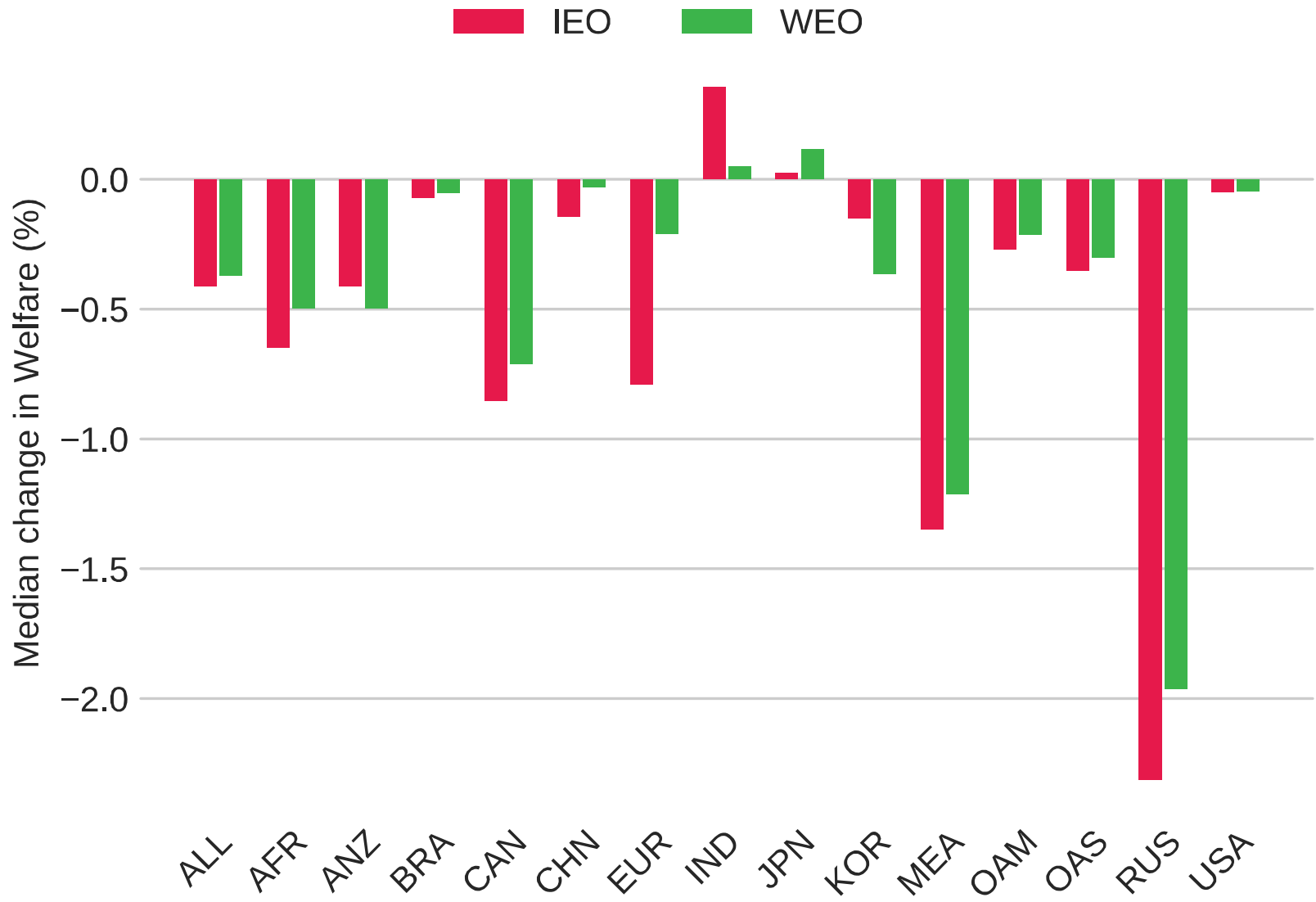
- NDC
- NDC+
- NDC-2C

### ***Cooperation***

- REF
- GLOBAL
- PARTIAL
- EUR\_CHN
- ASIA

# Regional Welfare

NDC, REF



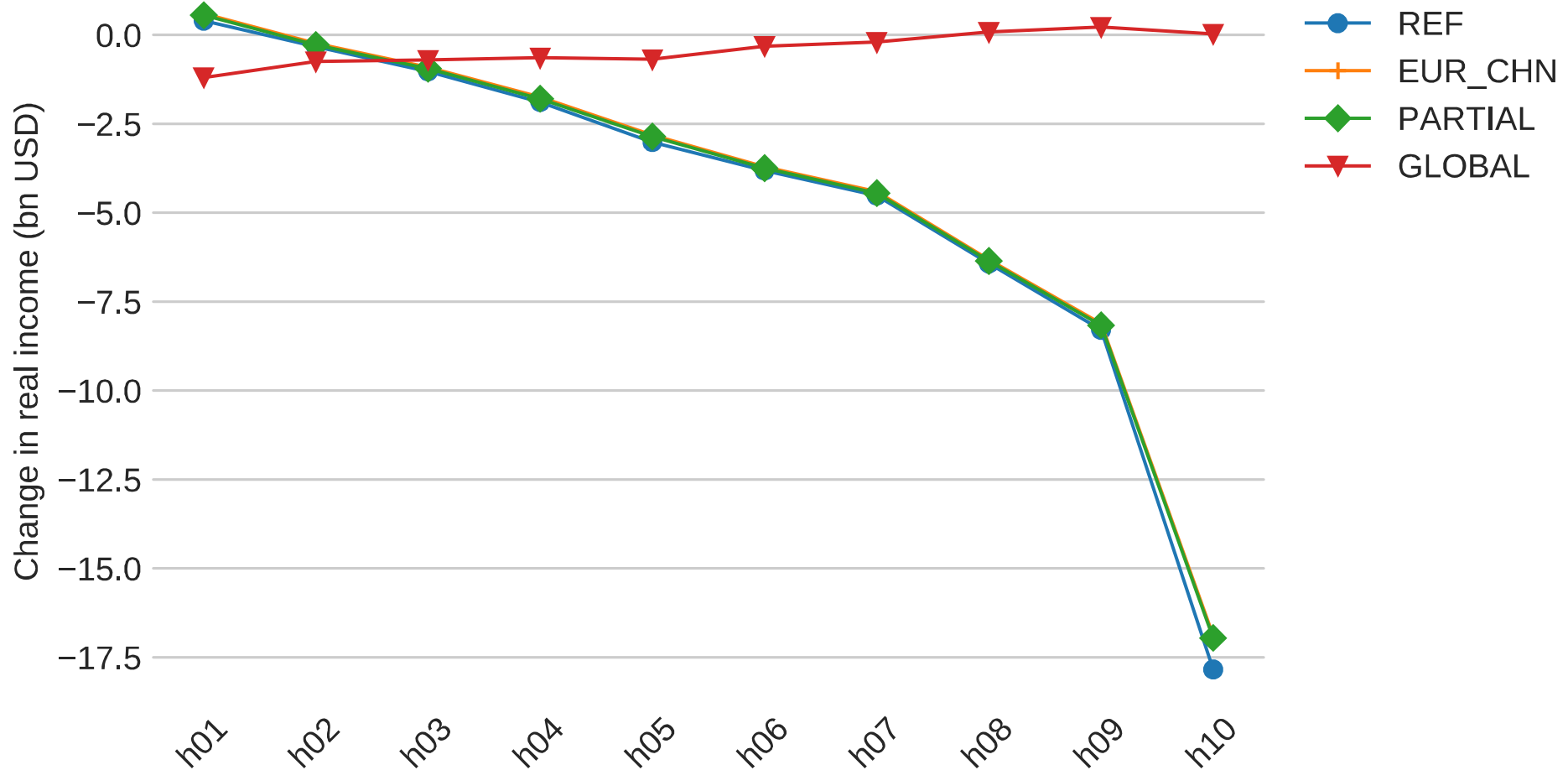
- Differences in translated NDCs and baseline assumptions (MACs)

# Household incidence analysis

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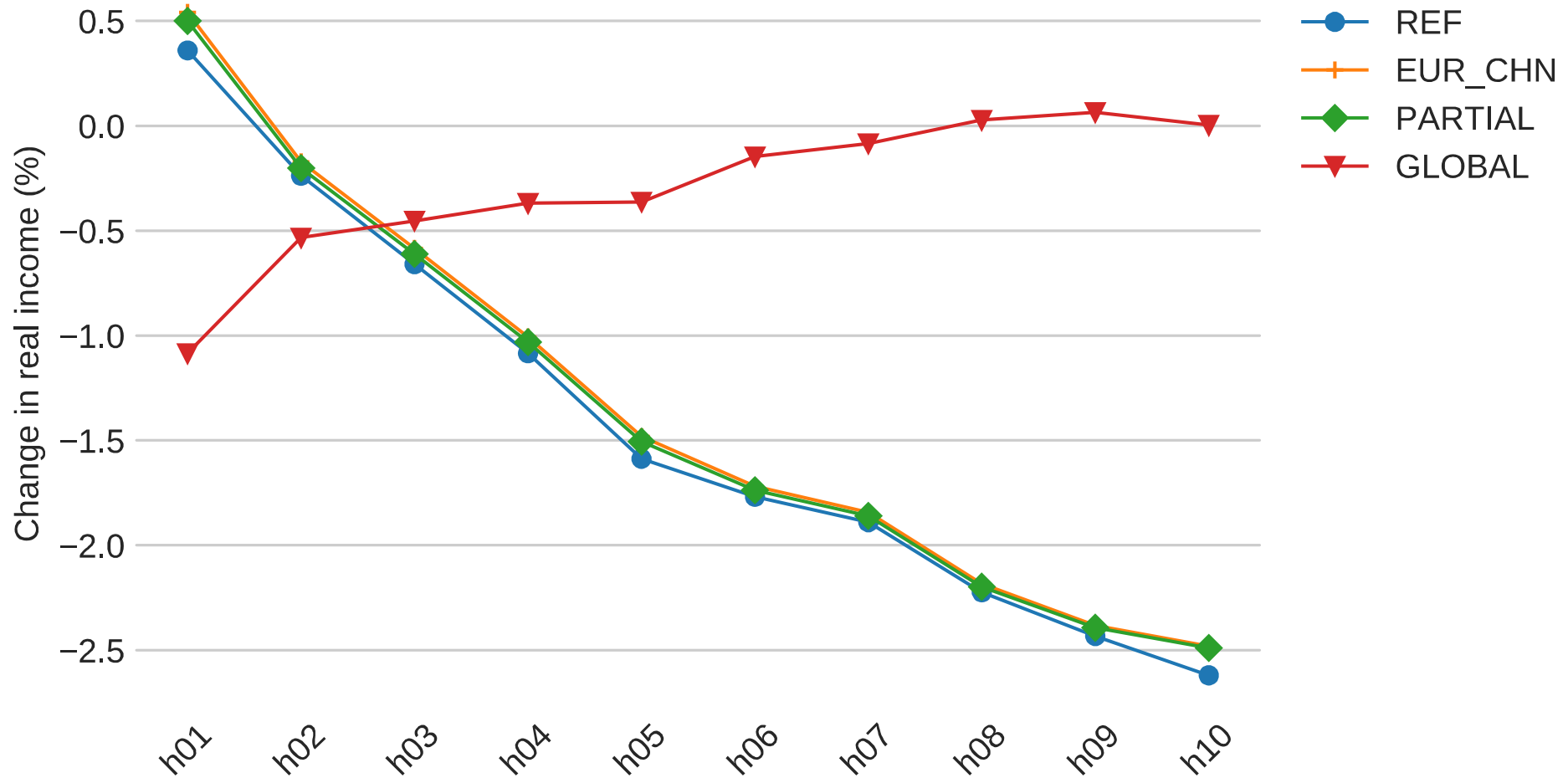
## Illustrative results for Germany

# Welfare – USD



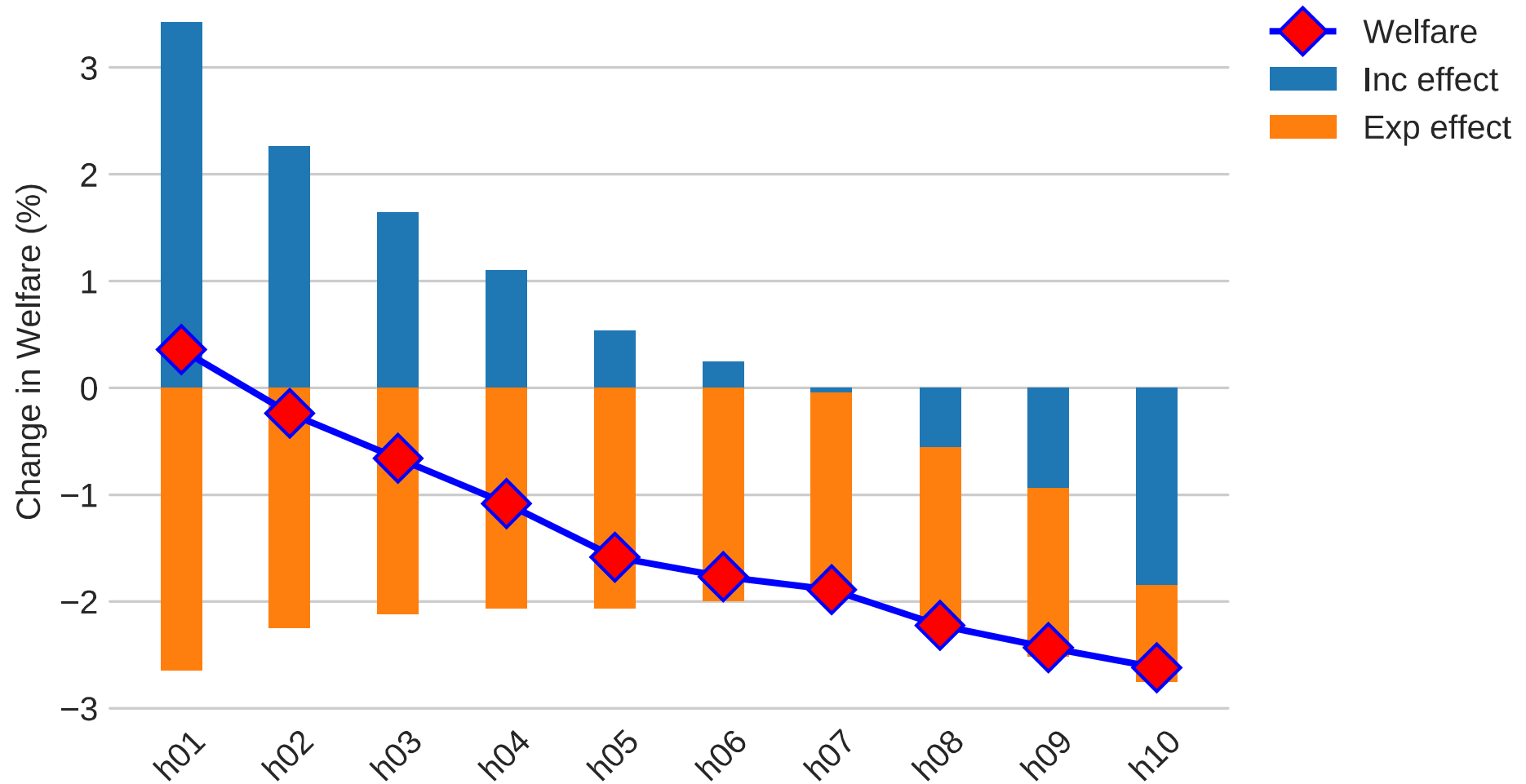
- Specific setup here: Transfers adjust to keep government expenditure constant
- GLOBAL: Effect of transfers outweighs CO<sub>2</sub> revenue redistribution

# Welfare – %



- Specific setup here: Transfers adjust to keep government expenditure constant
- GLOBAL: Effect of transfers outweighs CO<sub>2</sub> revenue redistribution

# Income and Expenditure Effects



# Social Welfare – EDE

