

# Climate Policies after Paris: Pledge, Trade and Recycle

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## Insights from the 36th Energy Modeling Forum Study (EMF36)

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# Energy Modeling Forum: Round 36

## ***Coordinators***

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  - Malte Winkler
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## ***Objectives***

- Medium-term economic assessment of initial Nationally Determined Contributions (NDCs) via systematic cross-comparison of results from internationally established energy-economy models
- Global and regional implications of different “Paris regimes” on welfare, CO<sub>2</sub> prices
- Household-level incidence in individual countries under different “Paris regimes”

# 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                              | ENVISAGE                    |
| ETH Zürich                                        | CEPE                        |
| CMCC                                              | CMCC                        |
| University of Graz                                | WEGDYN                      |
| Environmental Defense Fund                        | EDF-GEPA                    |
| European Commission - Joint Research Centre (JRC) | JRC-GEM-E3                  |
| University of Tsinghua                            | C-GEM                       |
| University of Fudan                               | DREAM                       |
| Technical University of Berlin                    | TUB                         |
| Centre for European Economic Research (ZEW)       | PACE                        |
| Basque Centre for Climate Change                  | BC3                         |
| Institute of Economic Growth (IEG)                | IEG                         |

# Study Design: Core Scenarios

## Business-as-Usual (BaU)

- *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: Regions and Sectors

| Countries and regions           | Sectors                                     |
|---------------------------------|---------------------------------------------|
| <i>Countries</i>                | <i>Energy</i>                               |
| United States (USA)             | Coal                                        |
| Canada (CAN)                    | Petroleum and coal products                 |
| Japan (JPN)                     | Crude oil                                   |
| South Korea (KOR)               | Natural gas                                 |
| Russia (RUS)                    | Electricity                                 |
| China (CHN)                     | <i>Other sectors/aggregates</i>             |
| India (IND)                     | Energy-intensive and trade-exposed (EITE)** |
| Brazil (BRA)                    | Transport                                   |
| <i>Aggregated regions</i>       | Agriculture                                 |
| Australia and New Zealand (ANZ) | Other manufacturing                         |
| Europe (EUR)*                   | Services                                    |
| Middle East (MEA)               |                                             |
| Africa (AFR)                    |                                             |
| Other Americas (OAM)            |                                             |
| Other Asia (OAS)                |                                             |

\* Includes EU27 + UK + EFTA members.

\*\* Includes chemical products; basic pharmaceutical products; rubber and plastic products; non-metallic minerals; mining of metal ores; iron and steel; non-ferrous metals; paper, pulp, and print.

# Study Design: Core Scenarios

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

| <b>BaU</b>   | <b>Ambition</b> | <b>Cooperation</b> |
|--------------|-----------------|--------------------|
| - <i>IEO</i> | - <i>NDC</i>    | - <i>ref</i>       |
| - <i>WEO</i> | - <i>NDC+</i>   | - <i>global</i>    |
|              | - <i>NDC-2C</i> | - <i>partial</i>   |
|              |                 | - <i>eur-chn</i>   |
|              |                 | - <i>asia</i>      |

## ***N.B.***

- Focus on *IEO*
- Denotation of scenarios with a “/”, e.g. *NDC/ref*

# Foreshadow of “Key” Results

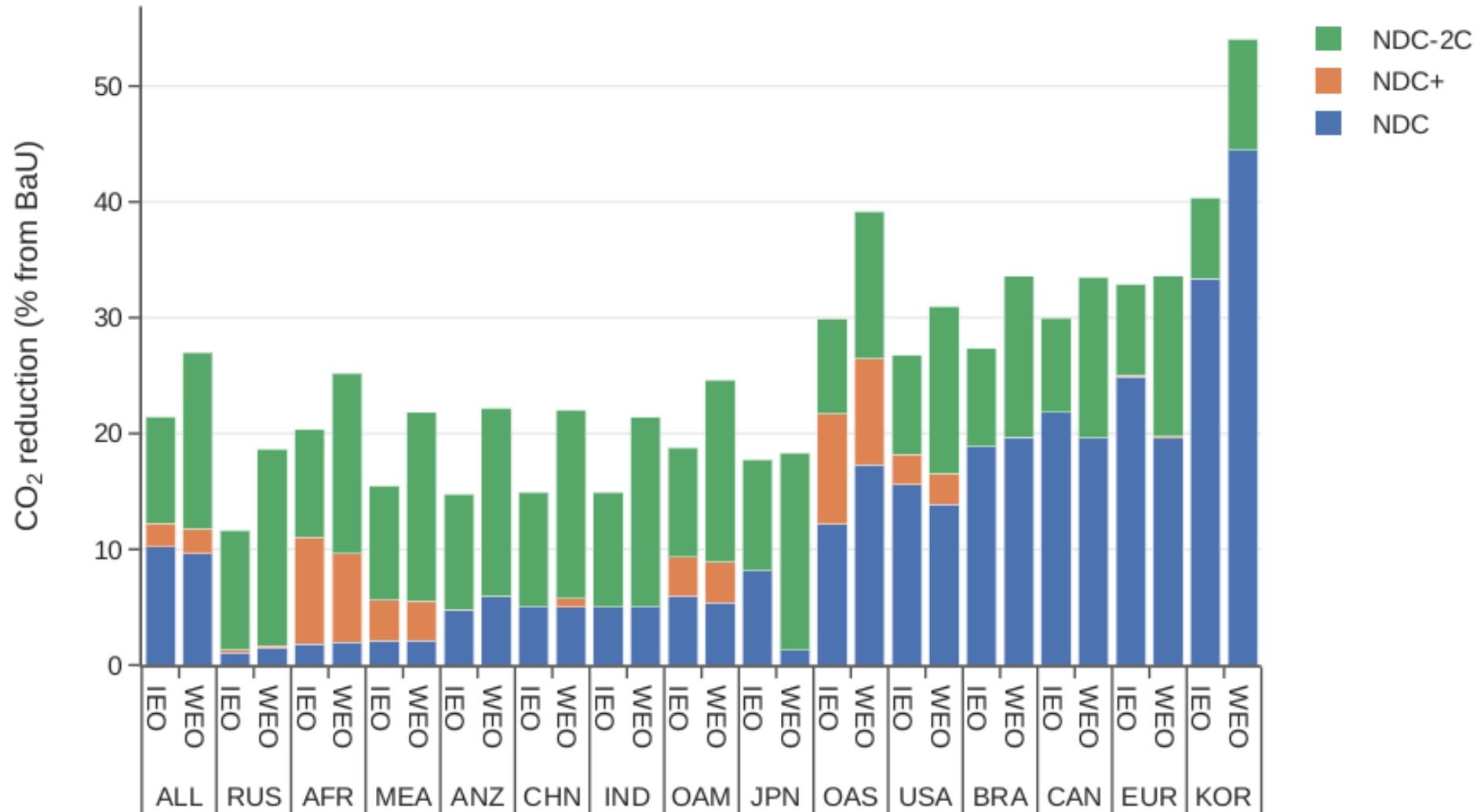
- Efficiency
  - *GLOBAL* scheme cuts global cost by 1/2 to 2/3 compared to *ref*
  - Rather limited global cost savings through EIT where-flexibility only
- Incidence
  - Strong incidence on oil and gas exporters under *ref* – some incidence shifting towards coal under *global*
  - South Korea and Europe 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

# Baseline Parameters – GDP

## (indexed to 2011)

| Region                        | CO <sub>2</sub>       |        |        | GDP         |        |        |
|-------------------------------|-----------------------|--------|--------|-------------|--------|--------|
|                               | 2011                  | 2030   |        | 2011        | 2030   |        |
|                               |                       | IEO    | WEO    |             | IEO    | WEO    |
|                               |                       |        |        |             |        |        |
|                               | Mt of CO <sub>2</sub> | 2011=1 | 2011=1 | billion USD | 2011=1 | 2011=1 |
| United States (USA)           | 5107                  | 0.89   | 0.90   | 15533       | 1.51   | 1.46   |
| Canada (CAN)                  | 523                   | 1.08   | 1.02   | 1778        | 1.38   | 1.45   |
| Japan (JPN)                   | 1028                  | 0.90   | 0.80   | 5905        | 1.13   | 1.18   |
| South Korea (KOR)             | 501                   | 1.20   | 1.44   | 1202        | 1.57   | 2.14   |
| Russia (RUS)                  | 1503                  | 0.95   | 1.05   | 1904        | 1.26   | 1.33   |
| China (CHN)                   | 7098                  | 1.14   | 1.28   | 7567        | 2.72   | 2.92   |
| India (IND)                   | 1771                  | 1.86   | 2.47   | 1880        | 3.01   | 3.80   |
| Brazil (BRA)                  | 372                   | 1.25   | 1.19   | 2476        | 1.32   | 1.39   |
| Australia & New Zealand (ANZ) | 411                   | 1.10   | 1.32   | 1550        | 1.64   | 2.14   |
| Europe (EUR)                  | 4211                  | 0.89   | 0.80   | 19182       | 1.29   | 1.34   |
| Middle East (MEA)             | 1808                  | 1.28   | 1.29   | 3372        | 1.74   | 1.77   |
| Africa (AFR)                  | 952                   | 1.33   | 1.40   | 2076        | 1.98   | 2.00   |
| Other Americas (OAM)          | 1167                  | 1.15   | 1.12   | 3471        | 1.60   | 1.55   |
| Other Asia (OAS)              | 2128                  | 1.48   | 1.70   | 3569        | 2.07   | 2.31   |

# Translated NDCs



- Global: Higher reduction requirement against *WEO*
- Regional: Biggest difference in BaUs for JPN, EUR, KOR

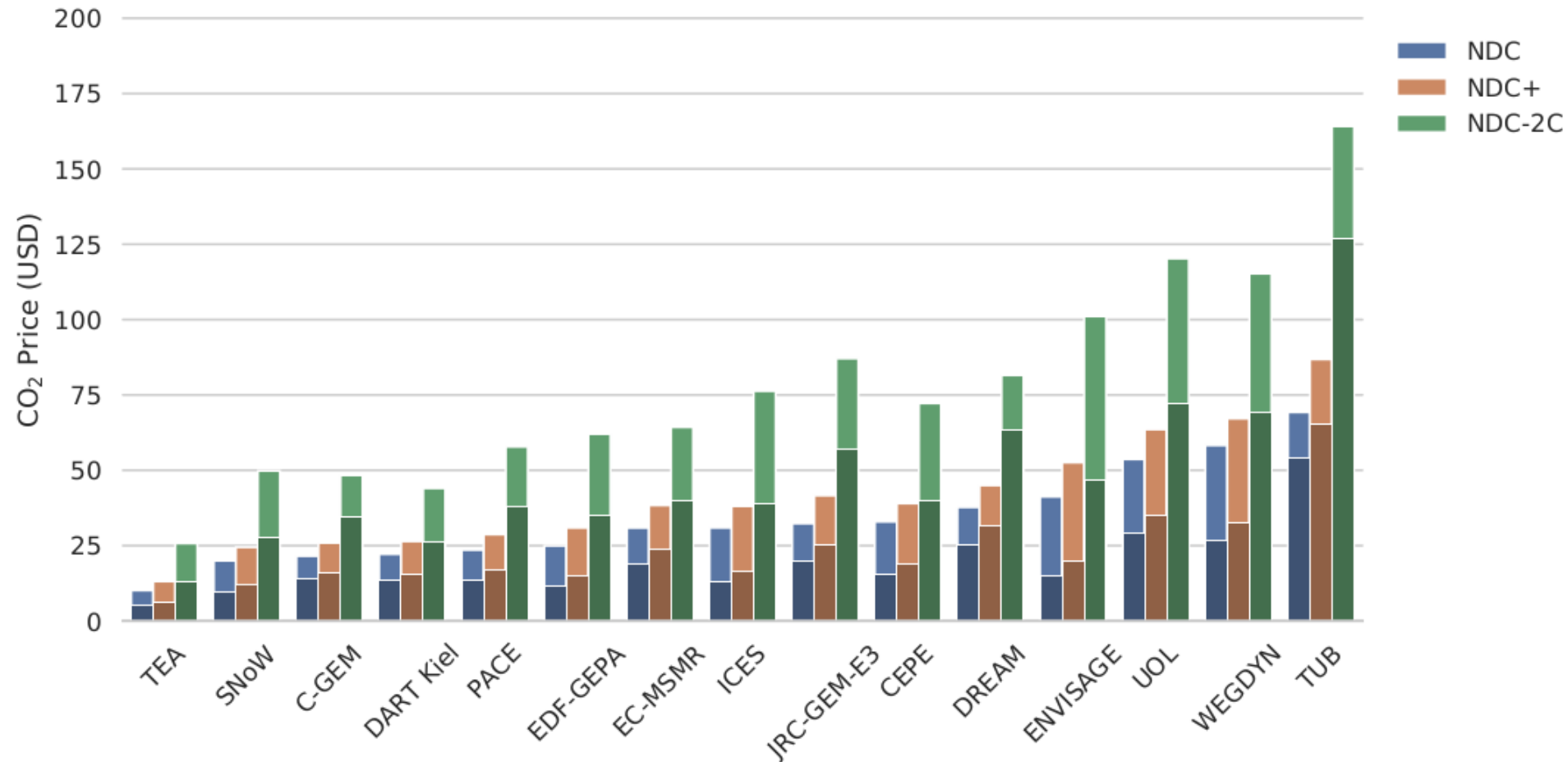
# Core Scenarios Overview

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

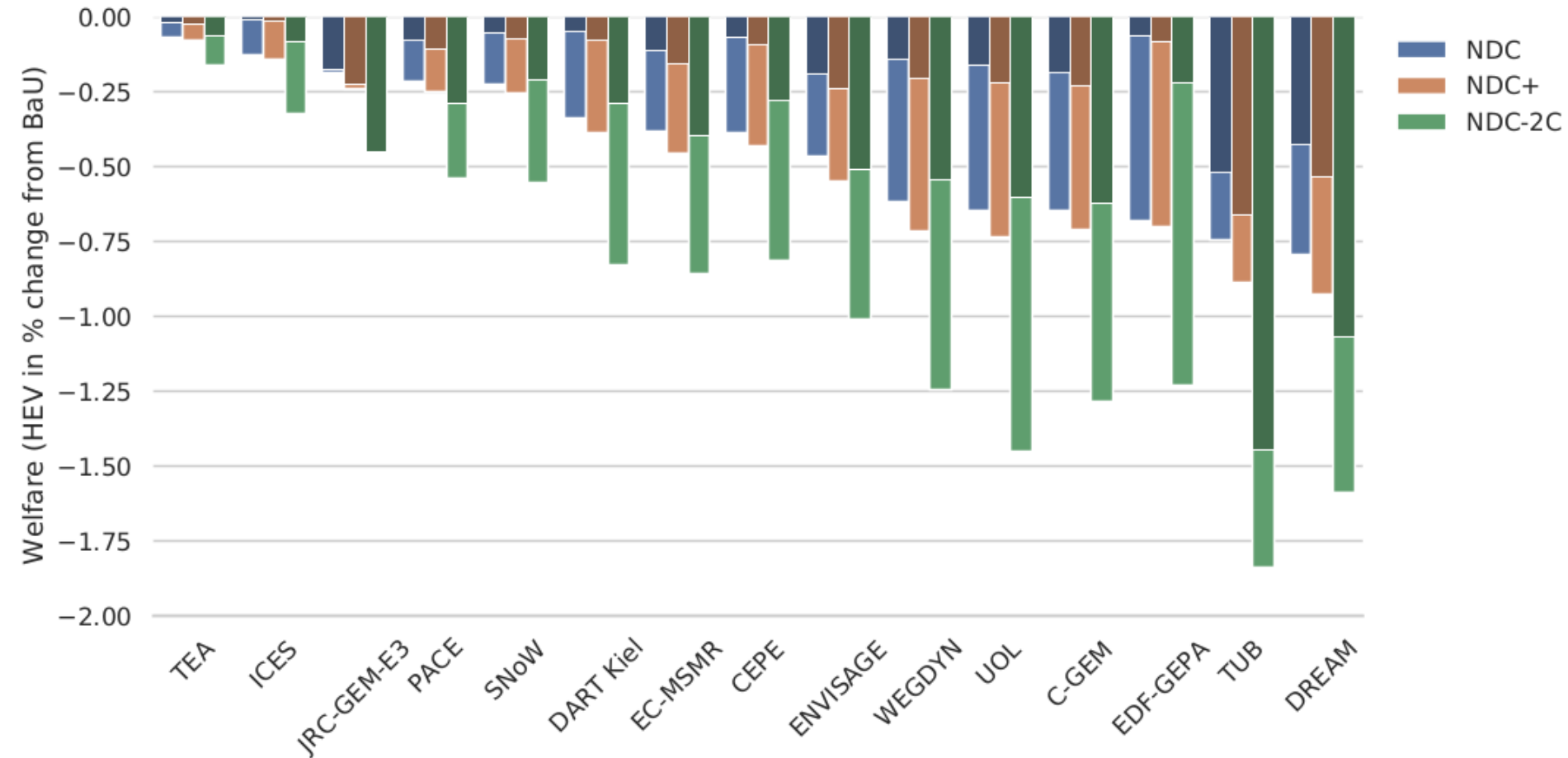
# Global Average CO<sub>2</sub> Price

IEO



- Broad range from 10-69 \$/tCO<sub>2</sub> under *NDC*, 26-164 \$/tCO<sub>2</sub> under *NDC-2C*
- Underlying: KLEM nesting, elasticities, baseline CO<sub>2</sub> prices

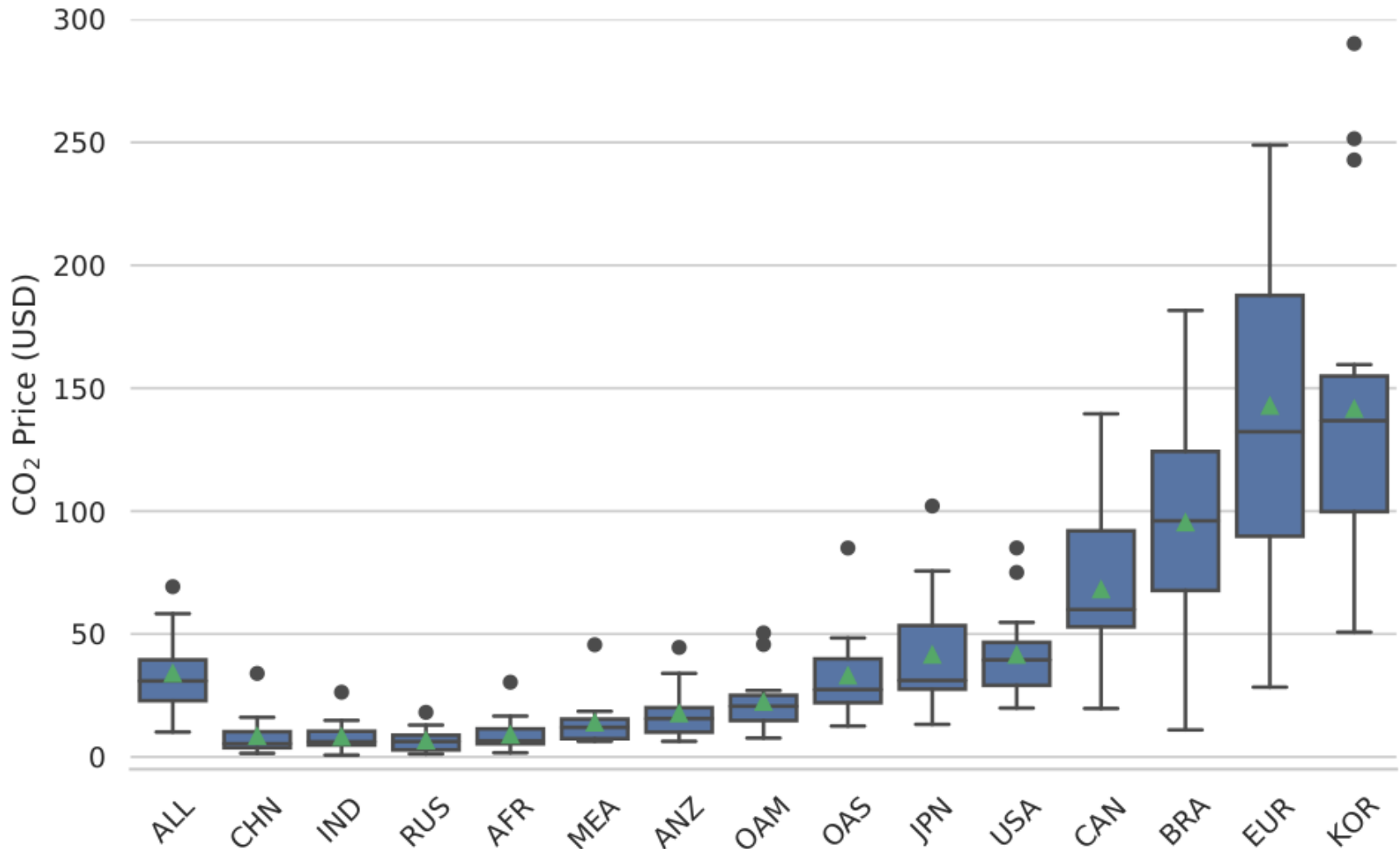
# Global Welfare



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

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

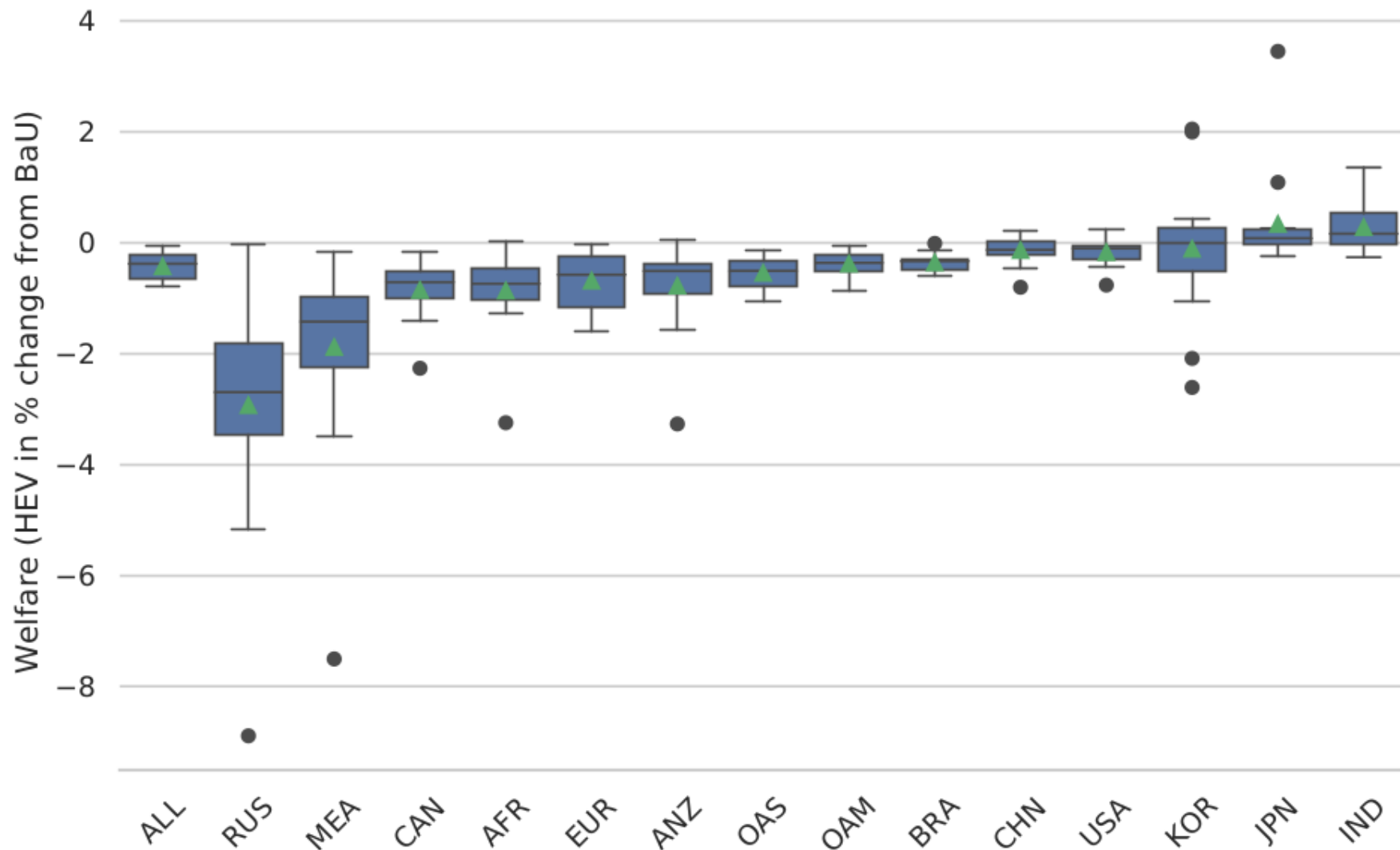
NDC/ref



- Underlying: MACs and reduction targets against BaU
- Marked variation across models

# Regional Welfare

*NDC/ref*



- Direct abatement costs (MACs)
- Terms-of-trade effects

## Baseline

- *IEO*
- *WEO*

## Ambition

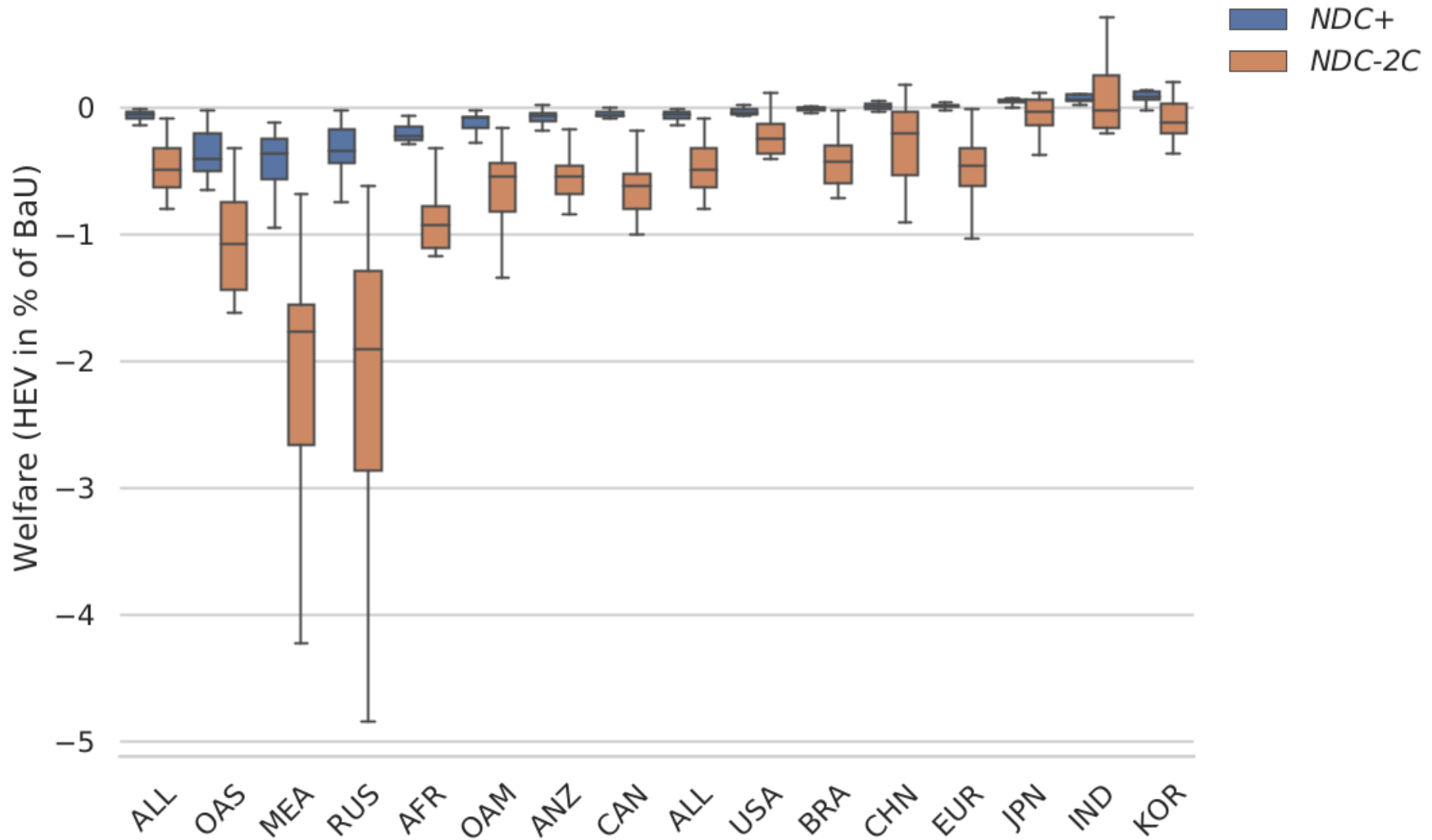
- *NDC*
- *NDC+*
- *NDC-2C*

## Cooperation

- *ref*
- *global*
- *partial*
- *eur-chn*
- *asia*

# Welfare: Ambition Level

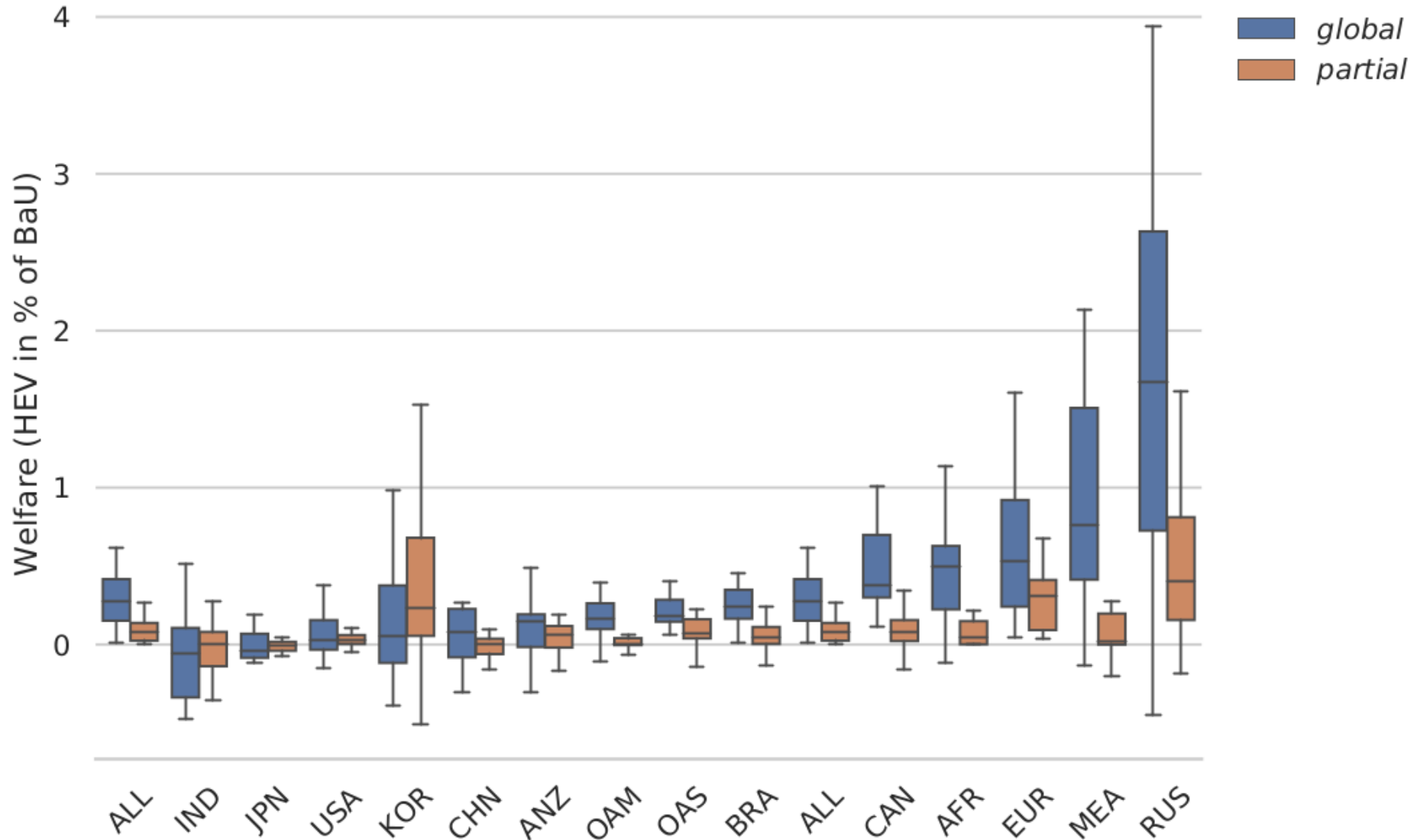
ref



- NDC+: Higher targets in Africa, Middle East, Other Americas and Other Asia
- NDC-2C: Additional global costs of about 0.5%-1%
- Fuel exporters Middle East and Russia lose over-proportionally

# Welfare: Global Cooperation

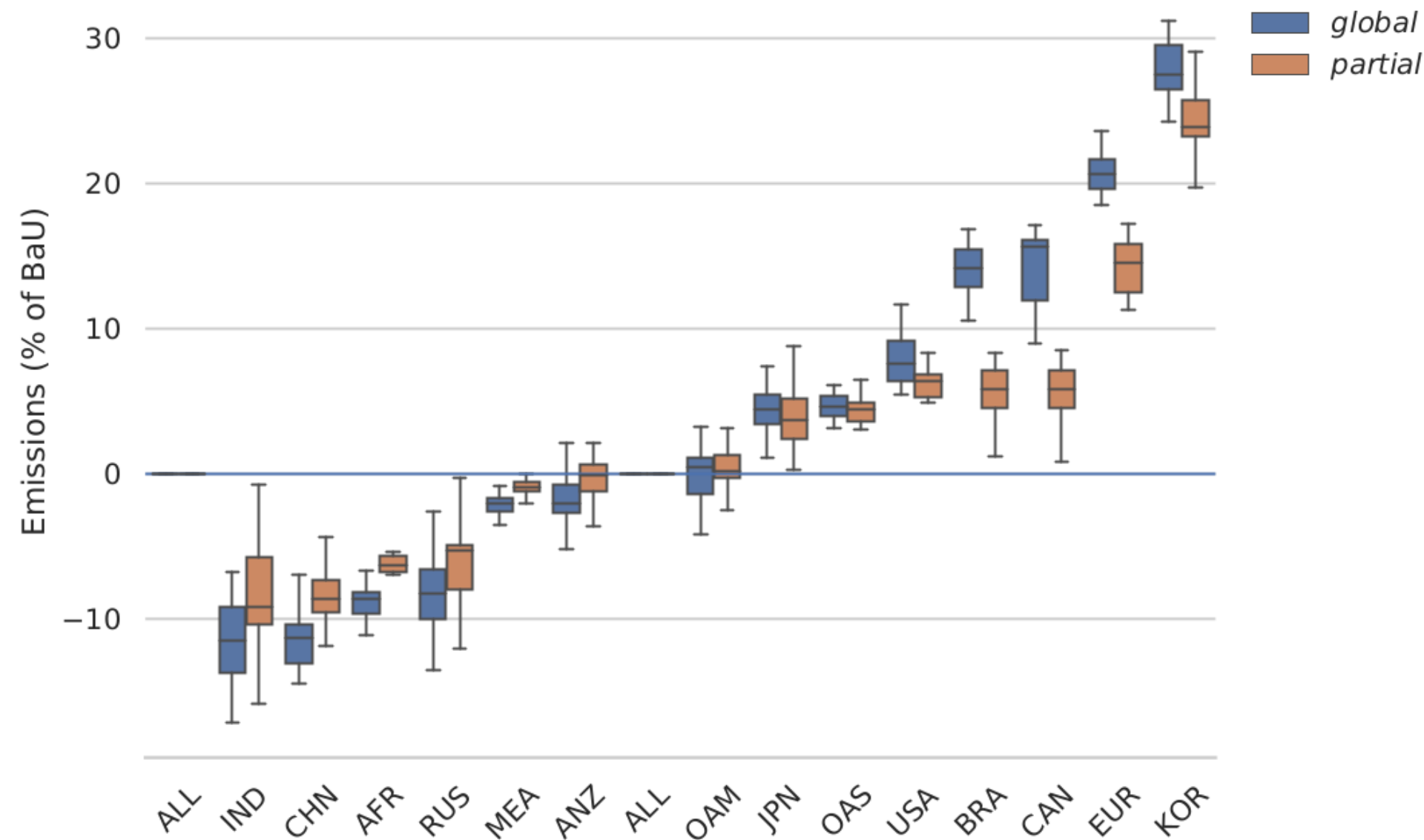
NDC



- Direct cost savings from emissions trading through MAC equalization
- ambiguous indirect welfare effects through changes in the terms of trade on energy and non-energy markets

# Emissions: International Cooperation

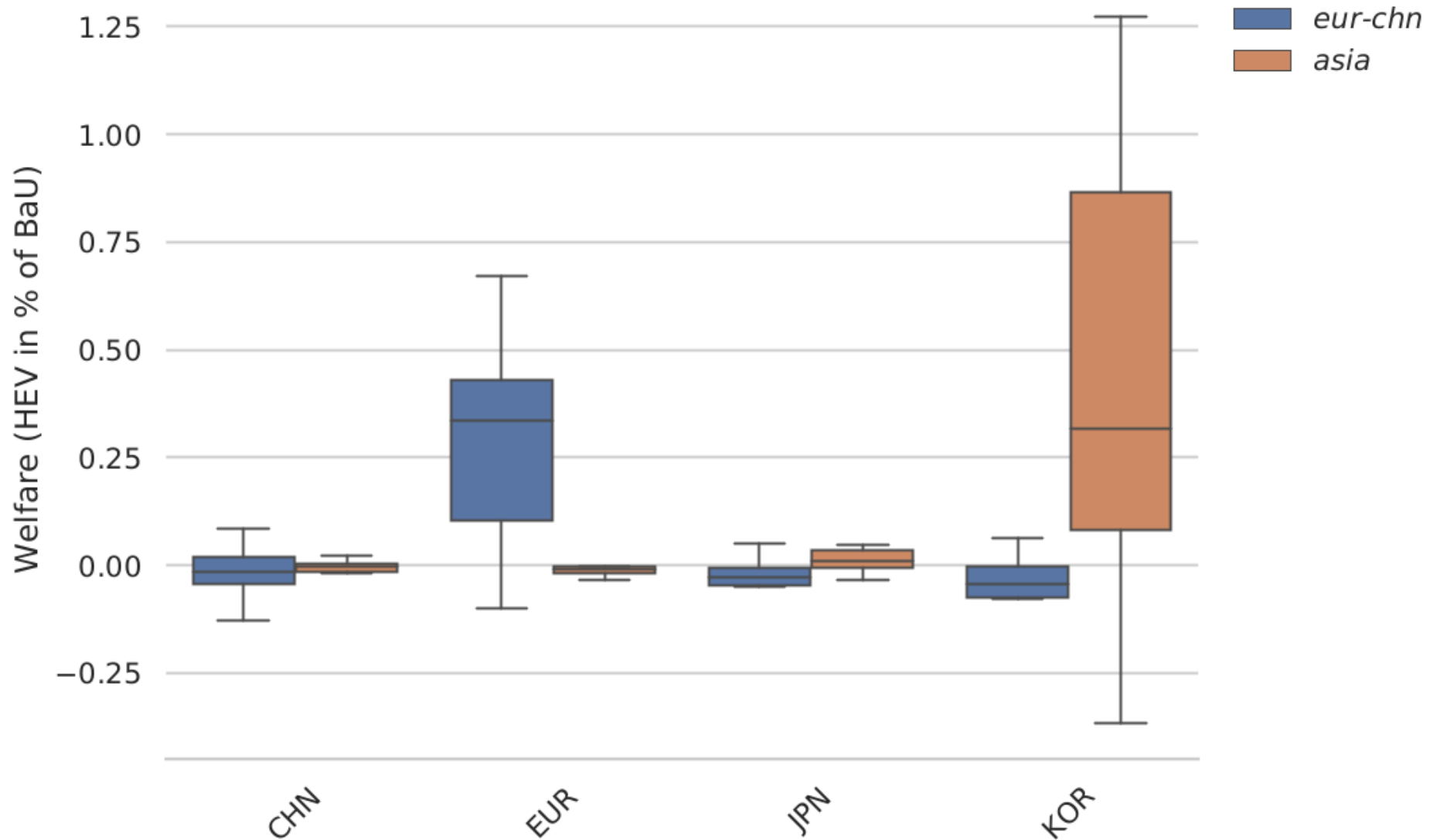
NDC



Note that Brazil is a large importer as our analysis focuses on CO<sub>2</sub> emissions from fuel combustion.

# Welfare: Club Trading

NDC



- Europe and South Korea gain from club trading (high CO<sub>2</sub> prices under *ref*)
- Only minor changes for other regions

# Incidence Across Households

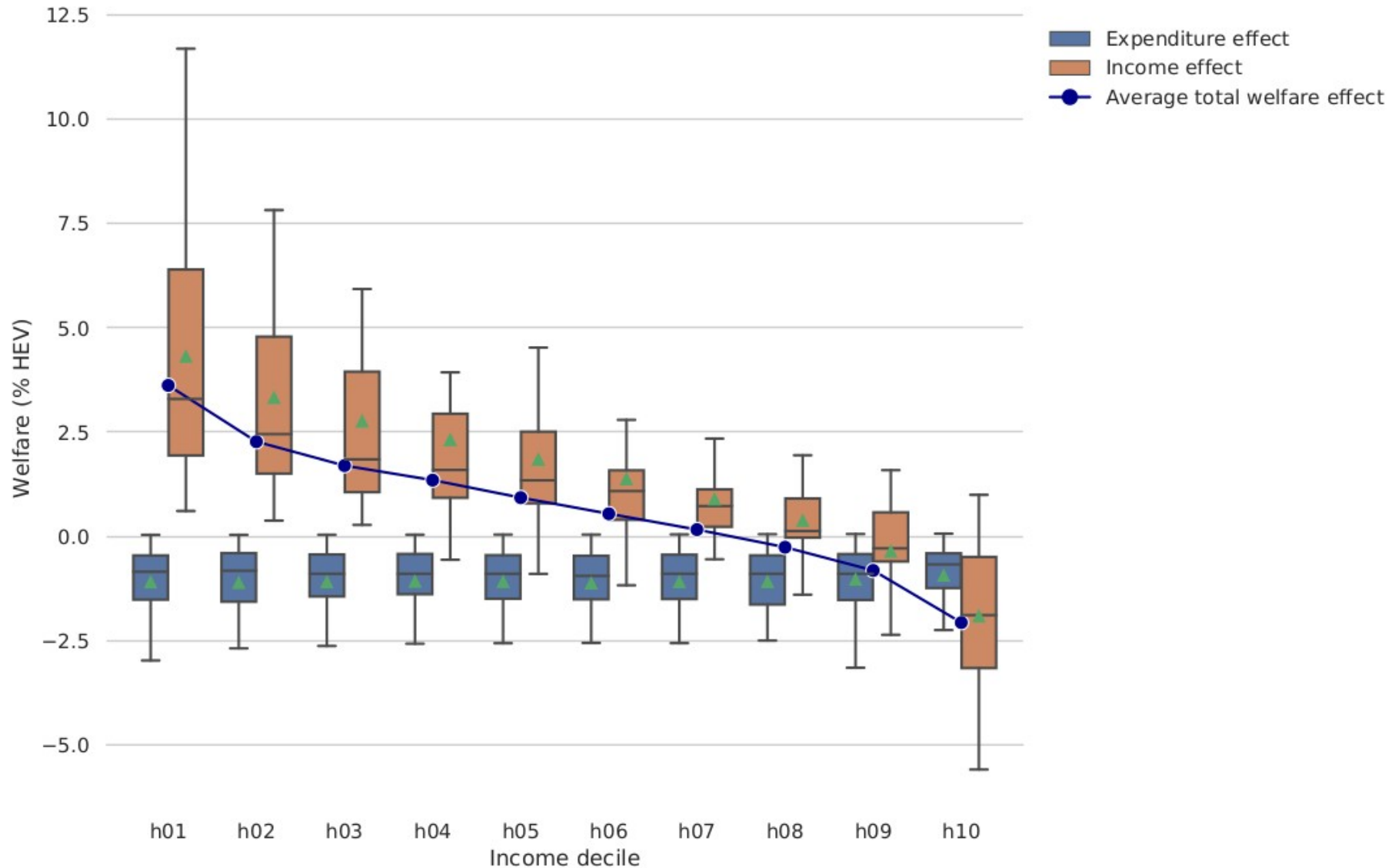
NDC

| Model      | Specification             | Specific country                                                                                                                                                                                  |
|------------|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BC3        | Single-country            | Spain                                                                                                                                                                                             |
| IEG        | Single-country            | India                                                                                                                                                                                             |
| TEA        | Multi-region              | Brazil                                                                                                                                                                                            |
| CEPE       | Multi-region              | Belgium, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Lithuania, Poland, Portugal, Slovakia, Slovenia, Spain, United Kingdom, Bulgaria, Croatia, Romania |
| JRC-GEM-E3 | Multi-region + soft-link* | Austria, Belgium, Czech Republic, Germany, Estonia, Greece, Spain, Finland, France, Italy, Romania                                                                                                |
| SNoW       | Multi-region              | Norway                                                                                                                                                                                            |
| DREAM      | Multi-region              | China                                                                                                                                                                                             |
| UOL        | Multi-region              | Germany                                                                                                                                                                                           |

\* JRC-GEM-E3 feeds its macroeconomic results for 11 European countries into the EUROMOD-ITT (Indirect Tax Tool) in order to perform the household impact assessment.

# Incidence Across Households

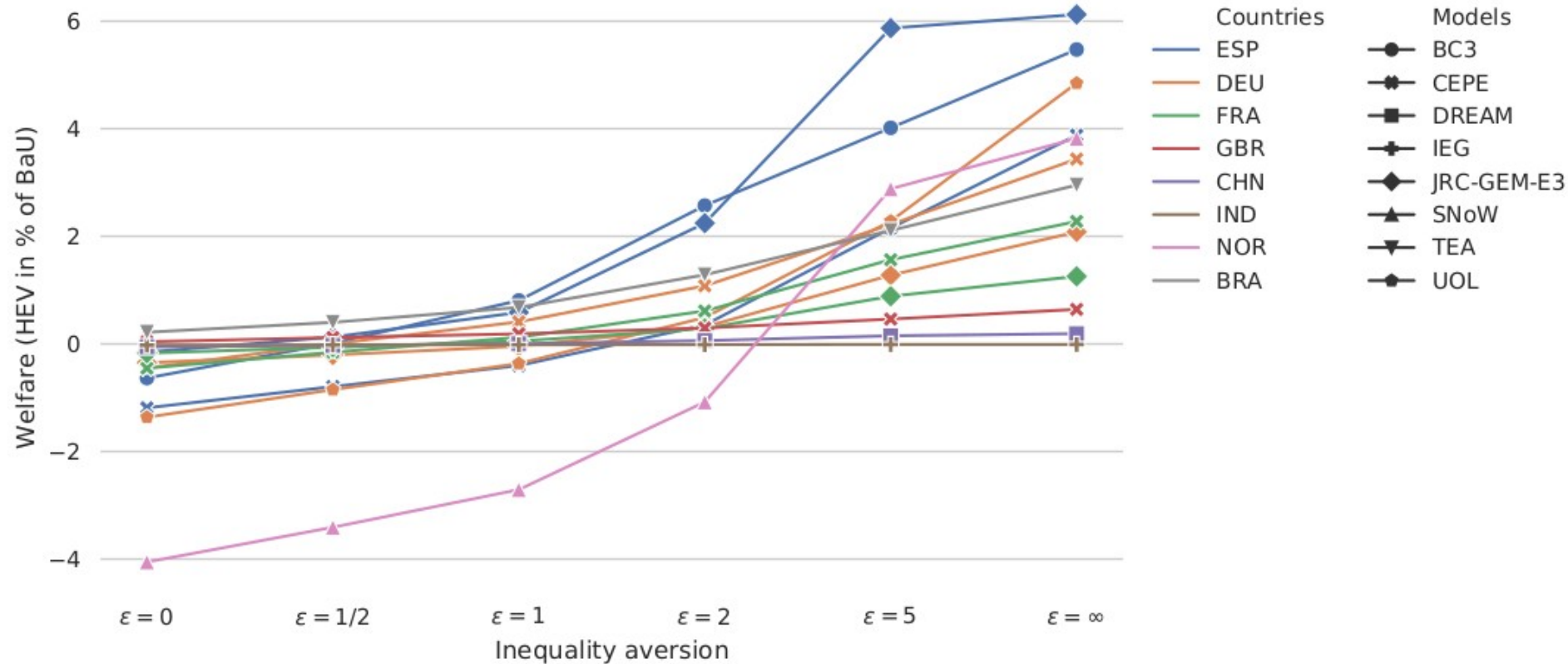
NDC



Income effect (incl. lump-sum rebates to households) dominates regressive expenditure effect

# Social Welfare (Atkinson)

NDC



Higher inequality aversion  $\rightarrow$  Higher progressiveness of the lump-sum rebates in equal shares to households across all considered countries

Thank You!