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_2 prices
- Household-level incidence under different "Paris regimes"

Results: Participating Groups/Models

Group	Model/Acronym
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_2 based on the International Energy Outlook (EIA)
- WEO   2030 GDP and CO_2 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	*Ambition*	*Cooperation*
- IEO	- NDC	- REF
- WEO	- NDC+	- GLOBAL
	- NDC-2C	- 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)

IEO

WEO

CAN
USA
BRA
JPN
KOR
CHN
IND
RUS
ANZ
EUR
MEA
AFR
OAM
OAS

Baseline Parameters – CO$_2$
(indexed to 2011)

IEO

WEO
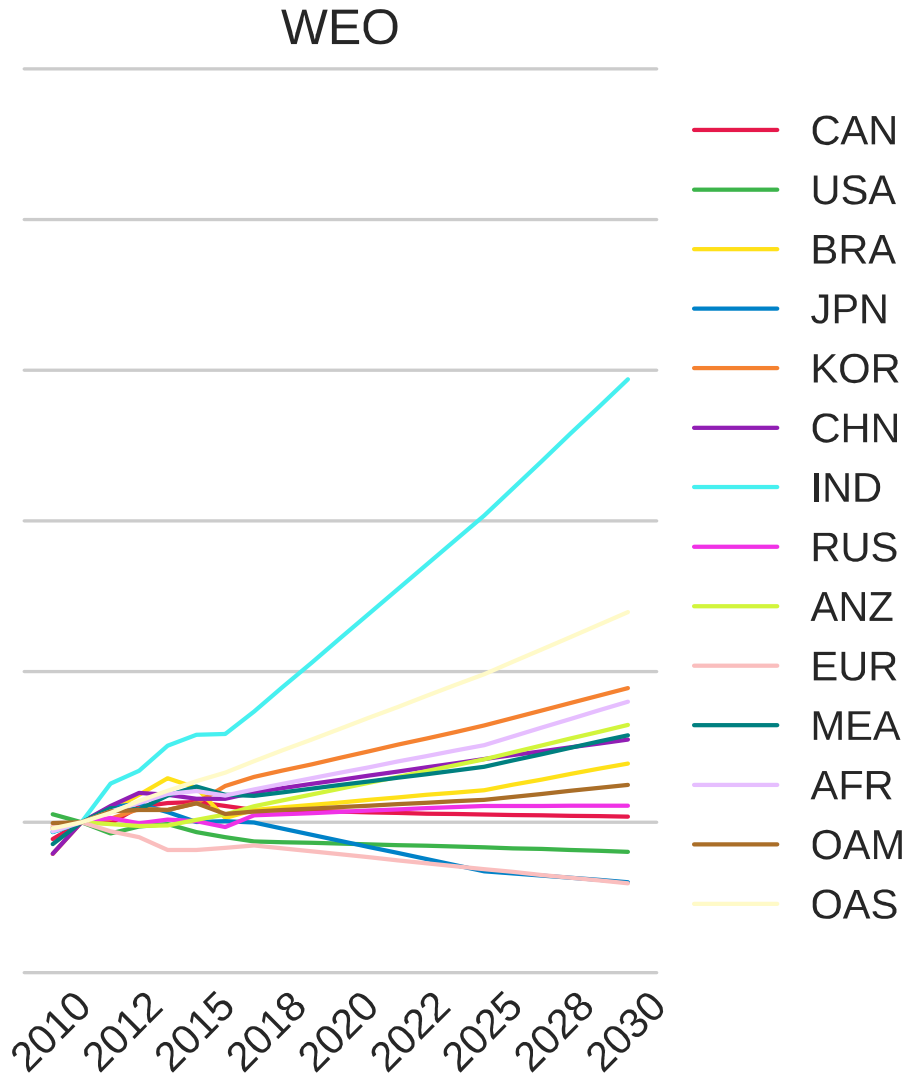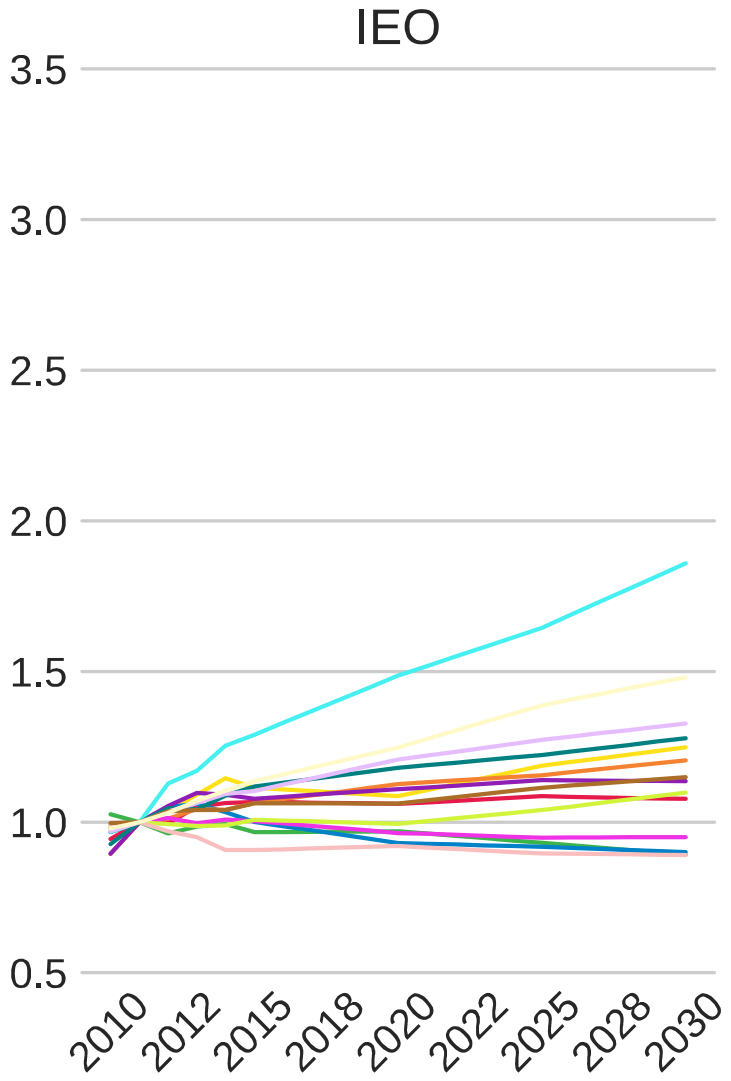
CAN
USA
BRA
JPN
KOR
CHN
IND
RUS
ANZ
EUR
MEA
AFR
OAM
OAS

Translated NDCs – IEO
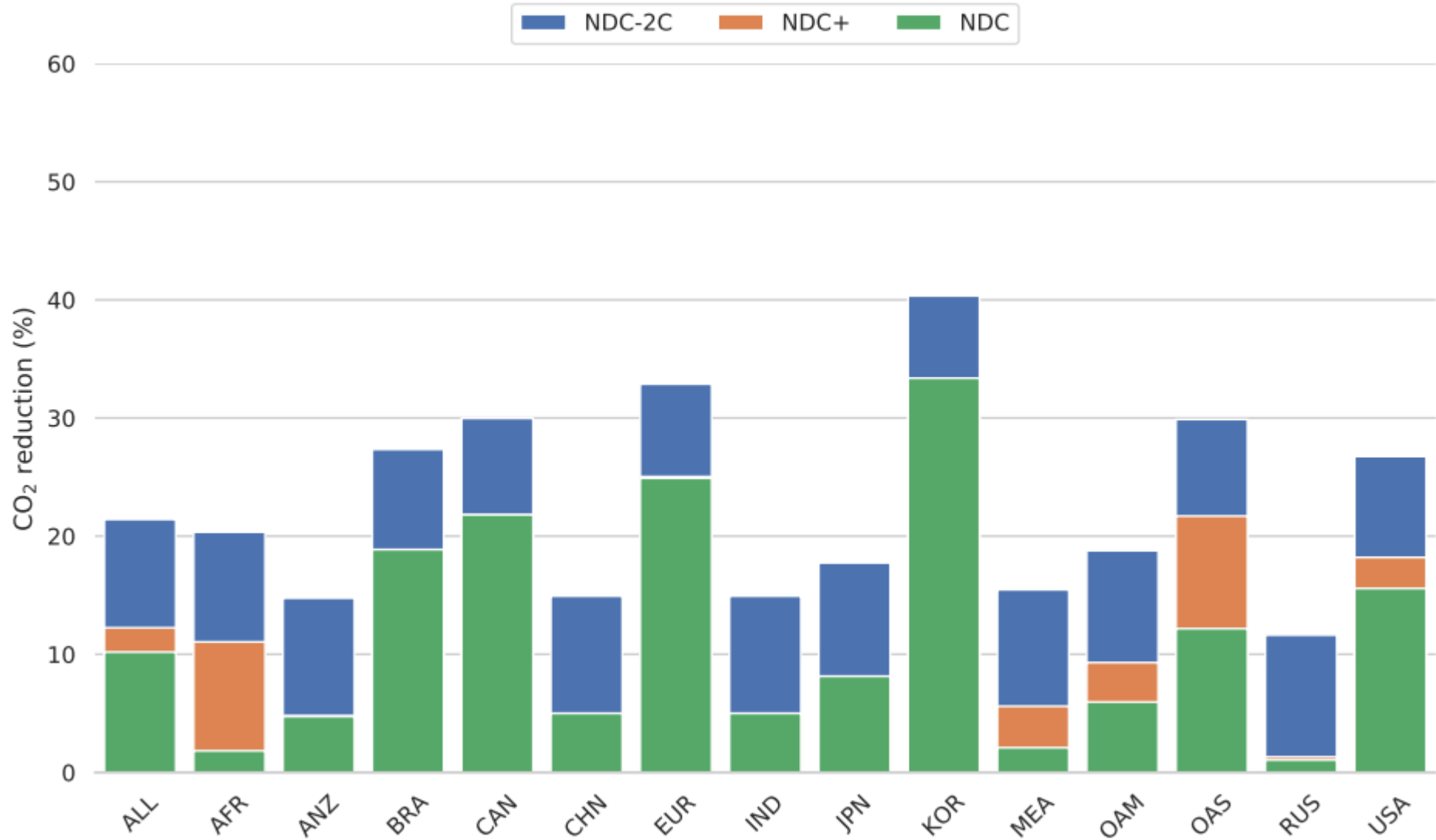
Translated NDCs – WEO
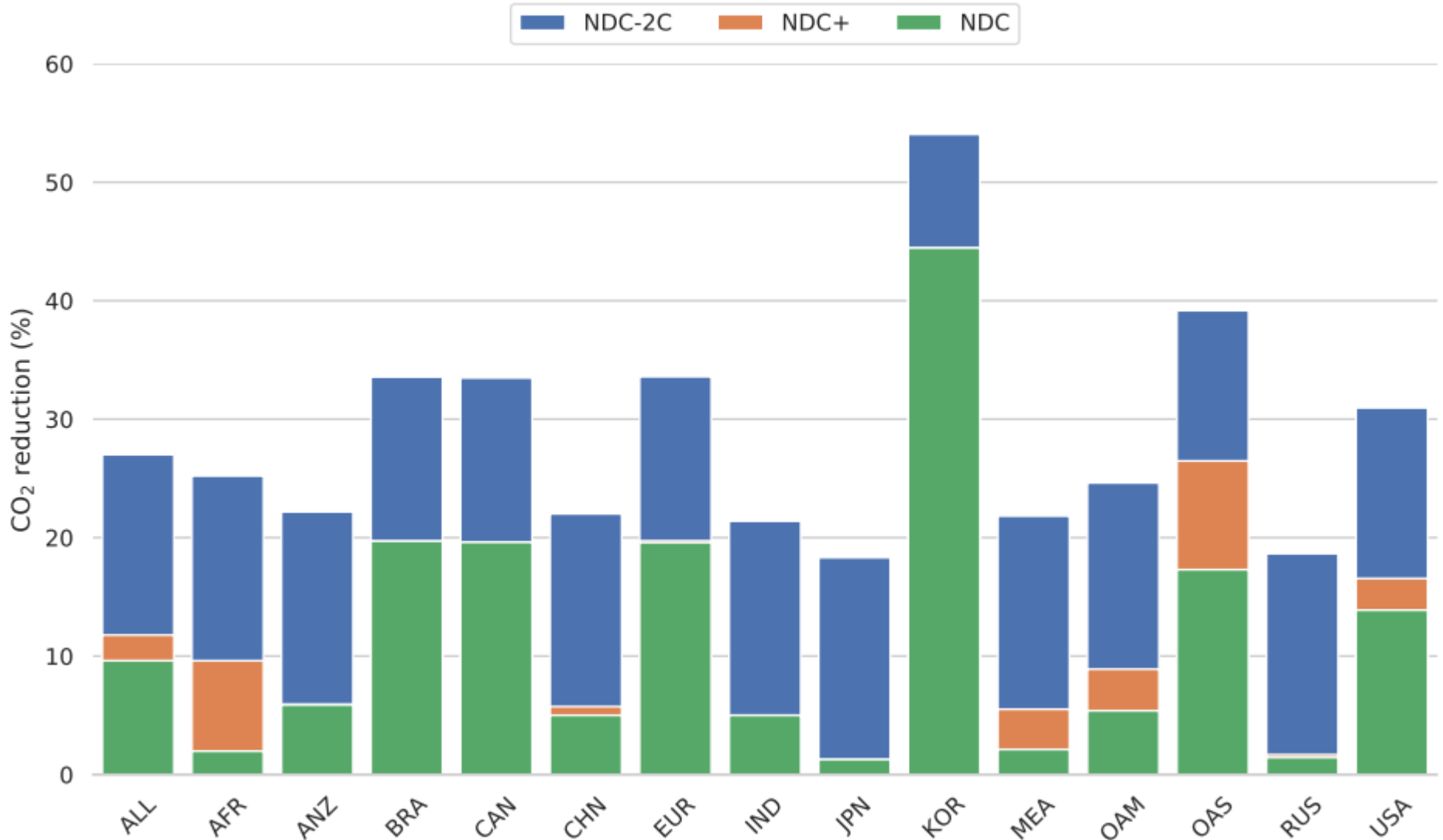
- More emission growth in the WEO baseline → Higher reduction requirements to achieve NDC-2C
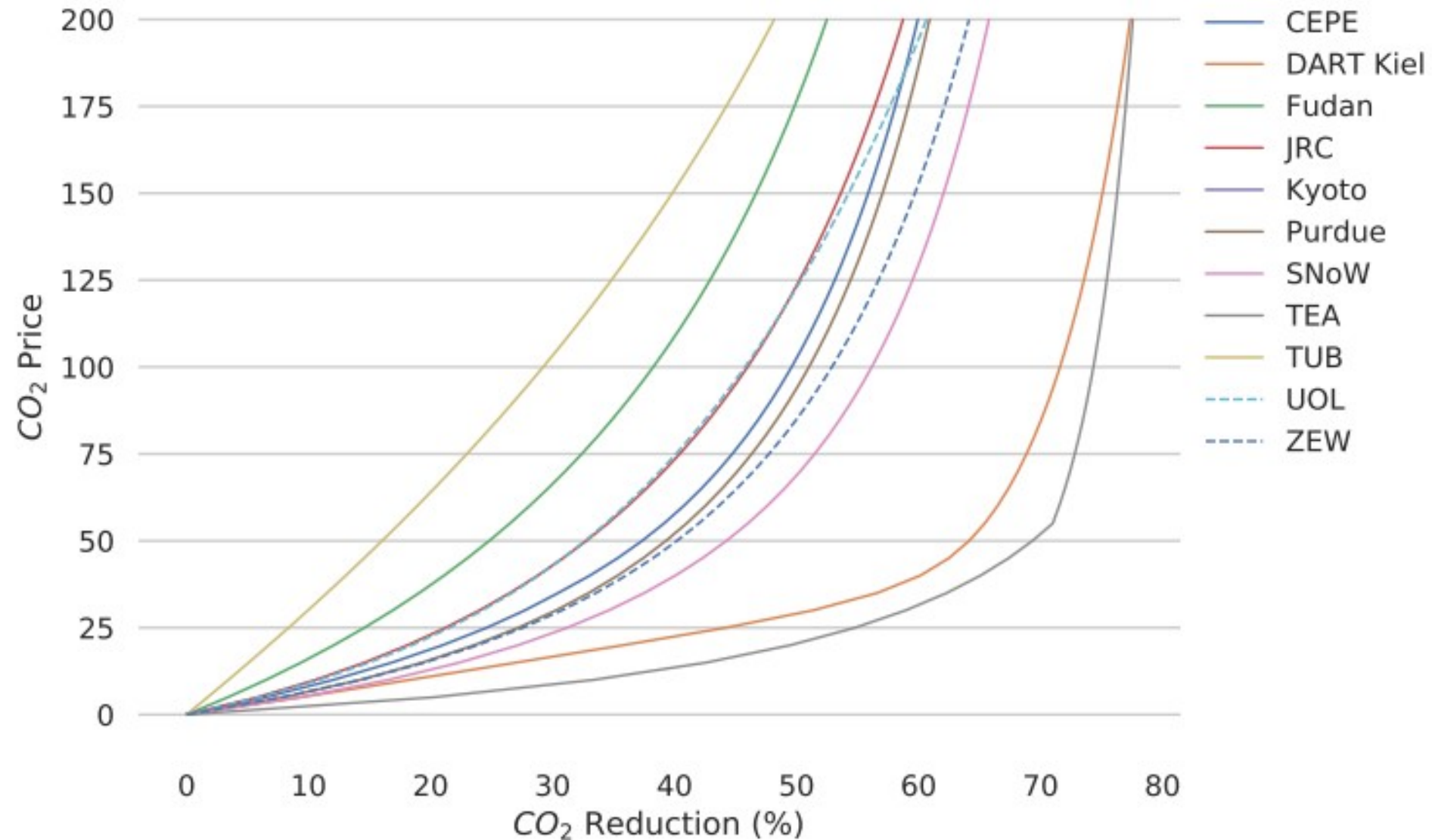
MAC Curves – Europe/EUR (%)
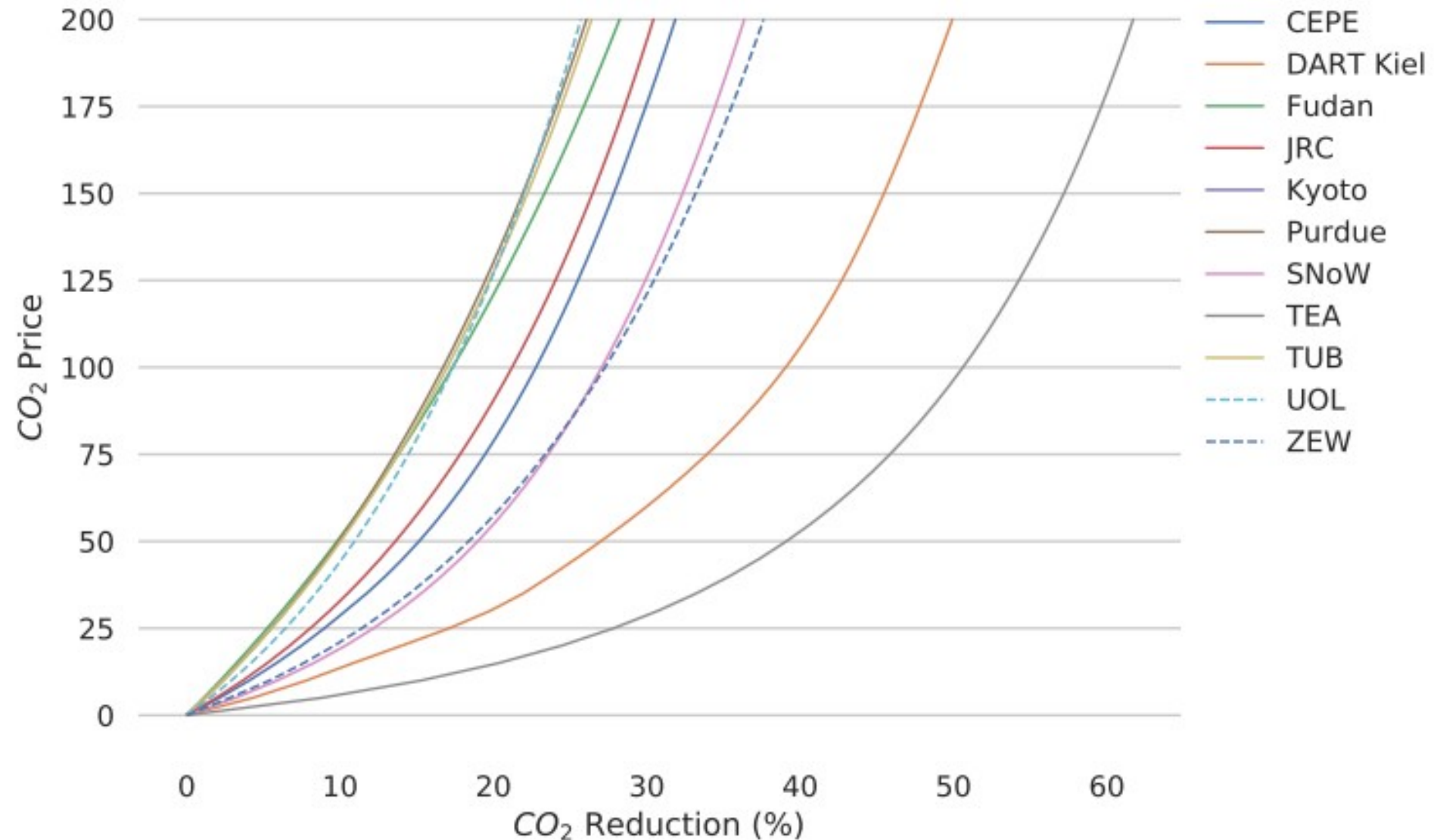
- Main drivers for MAC differences include elasticities (KLEM – interfuel), baseline (explicit and implicit) CO_2 prices, energy prices

MAC Curves – USA (%)
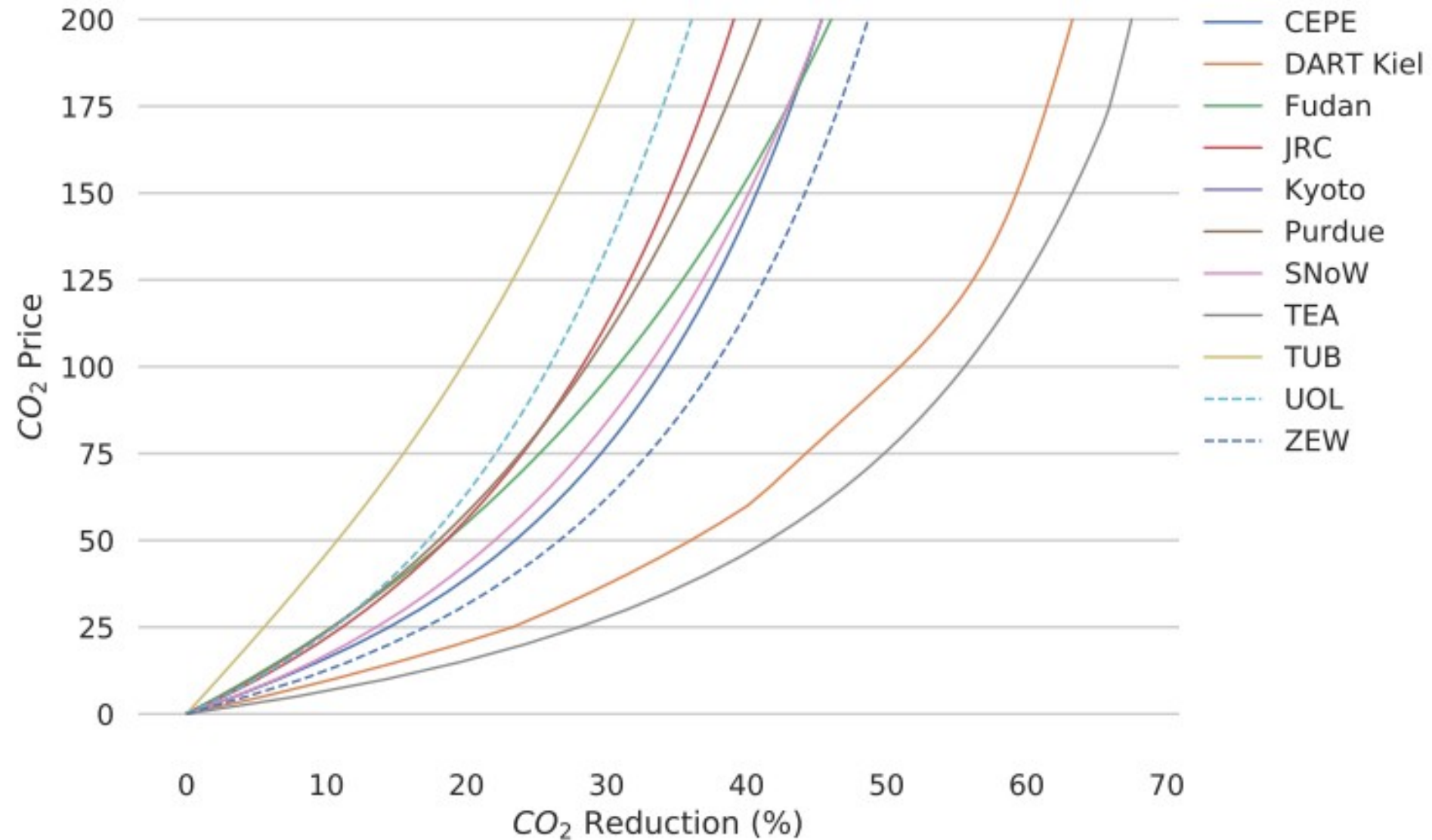
MAC Curves – China/CHN (%)

- China and India with substantial amounts of cheap abatement options

MAC Curves – India/IND (%)

MAC Curves – Russia/RUS (%)
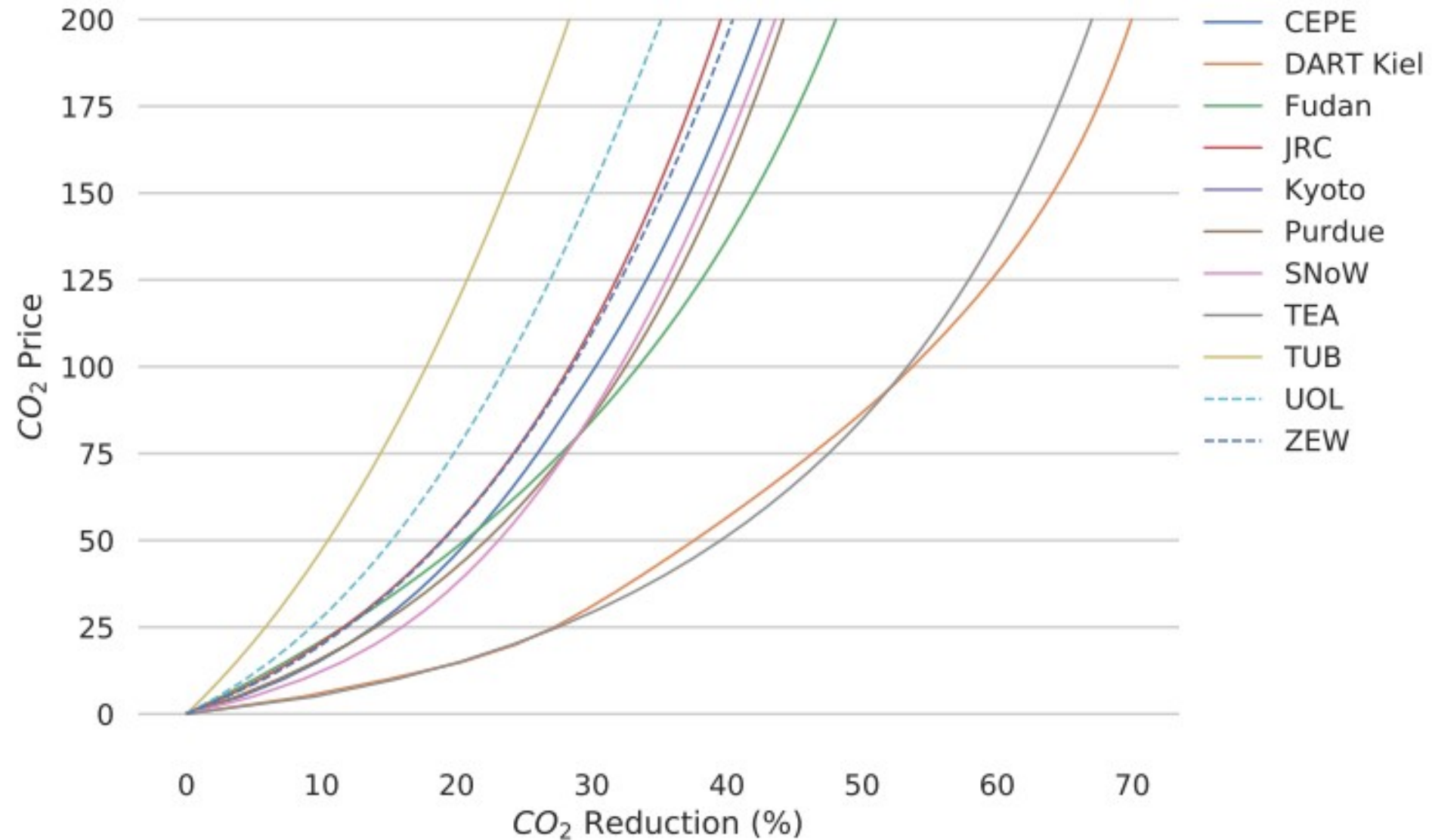
Core Scenarios Overview

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Global welfare, GDP, CO_2 prices under *REF* and *GLOBAL*

Global Welfare
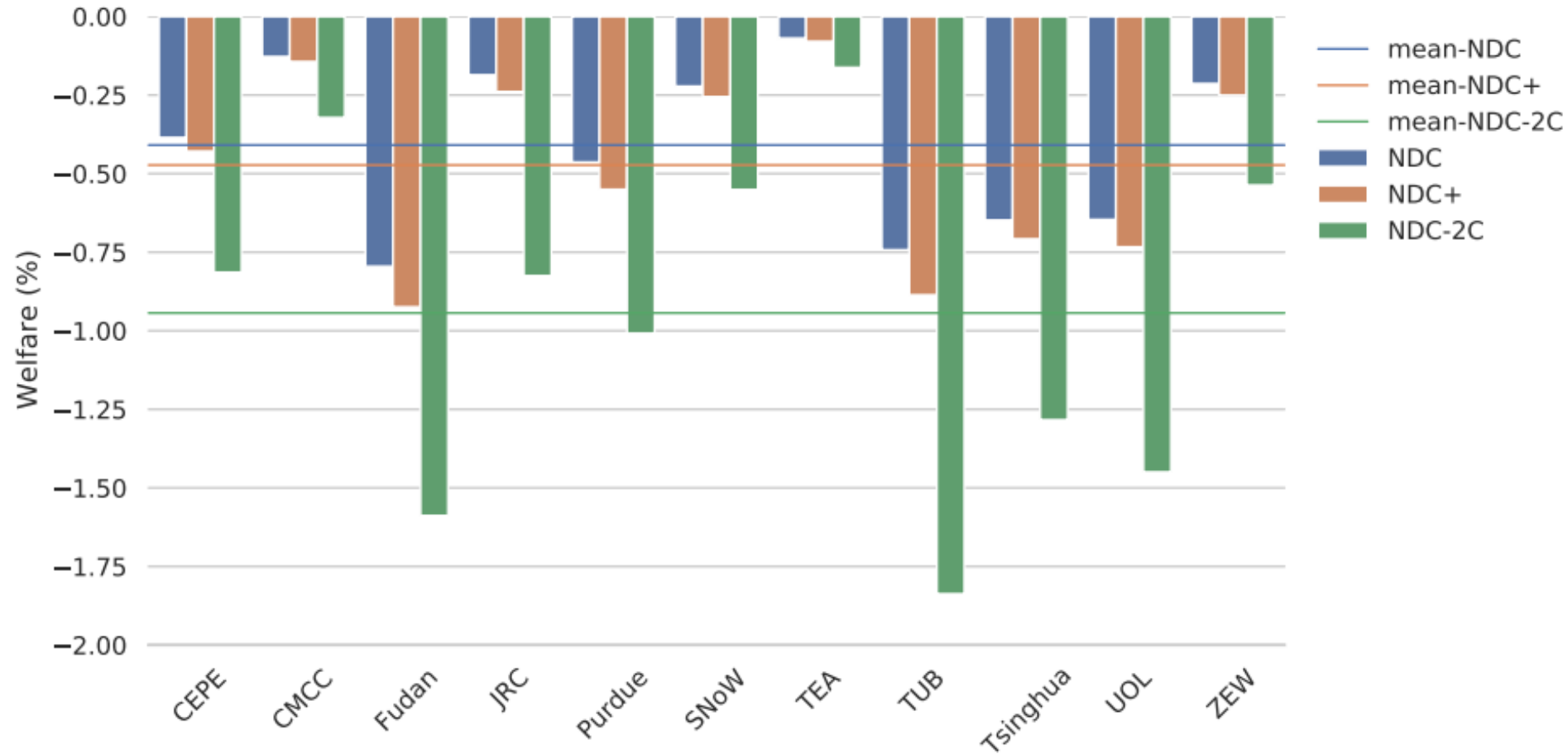
- Underlying: MACs

- Marked variation across models

- Rough doubling of cost from NDC/NDC+ to NDC-2C

Global Welfare
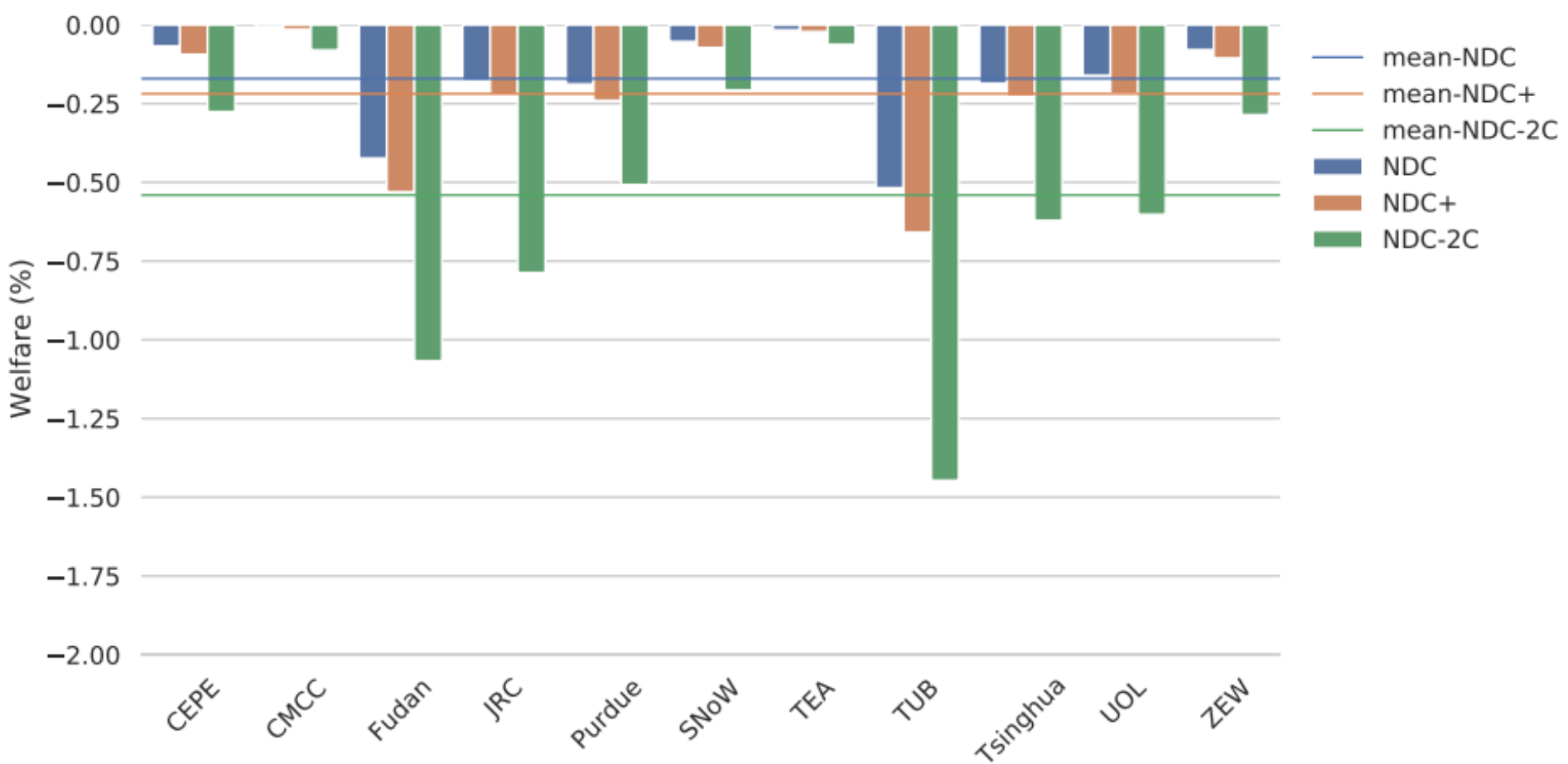
- Huge cost savings from global scheme (cut by 1/2 to 2/3)

- Higher relative savings for lower ambition (shape/convexity of MACs)
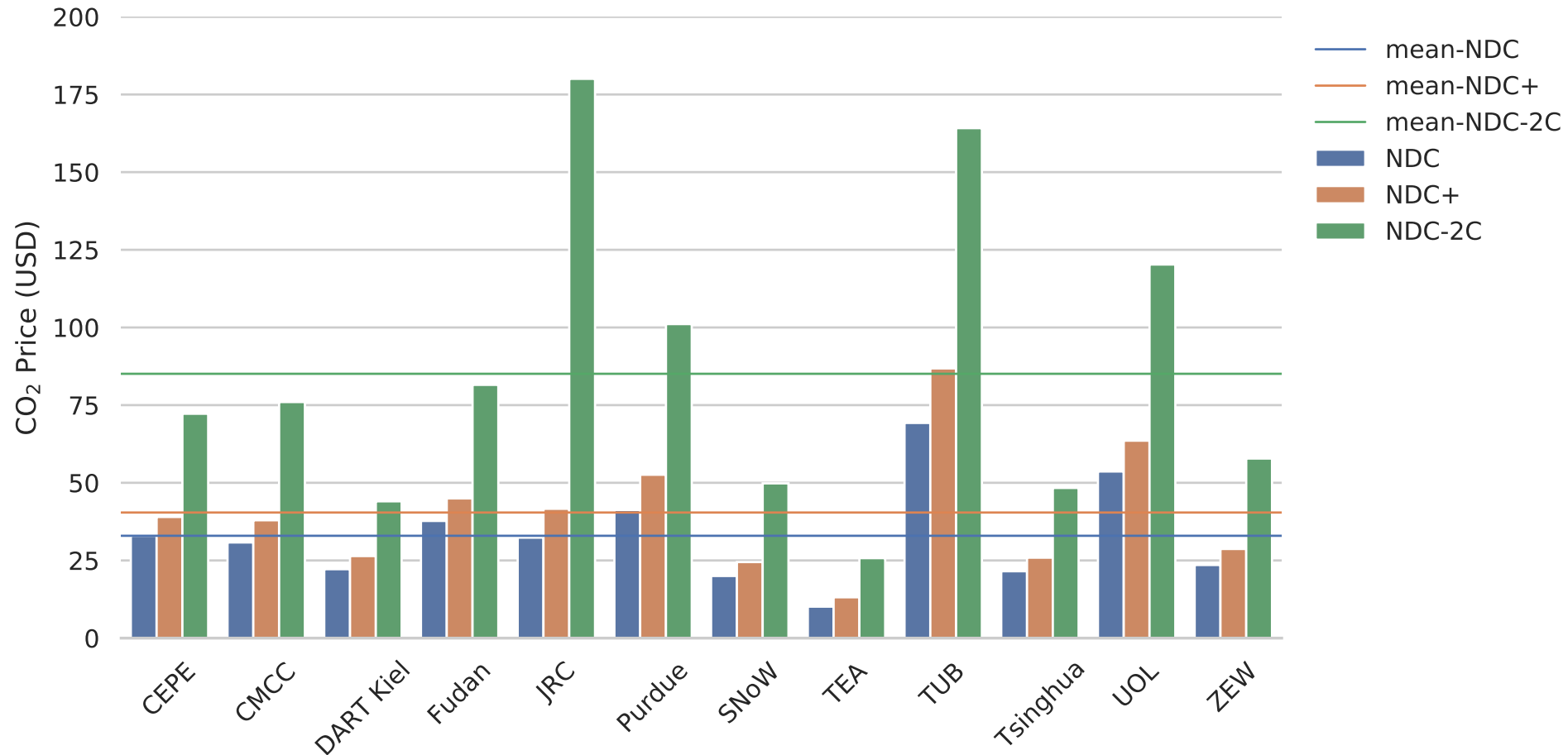
Global GDP
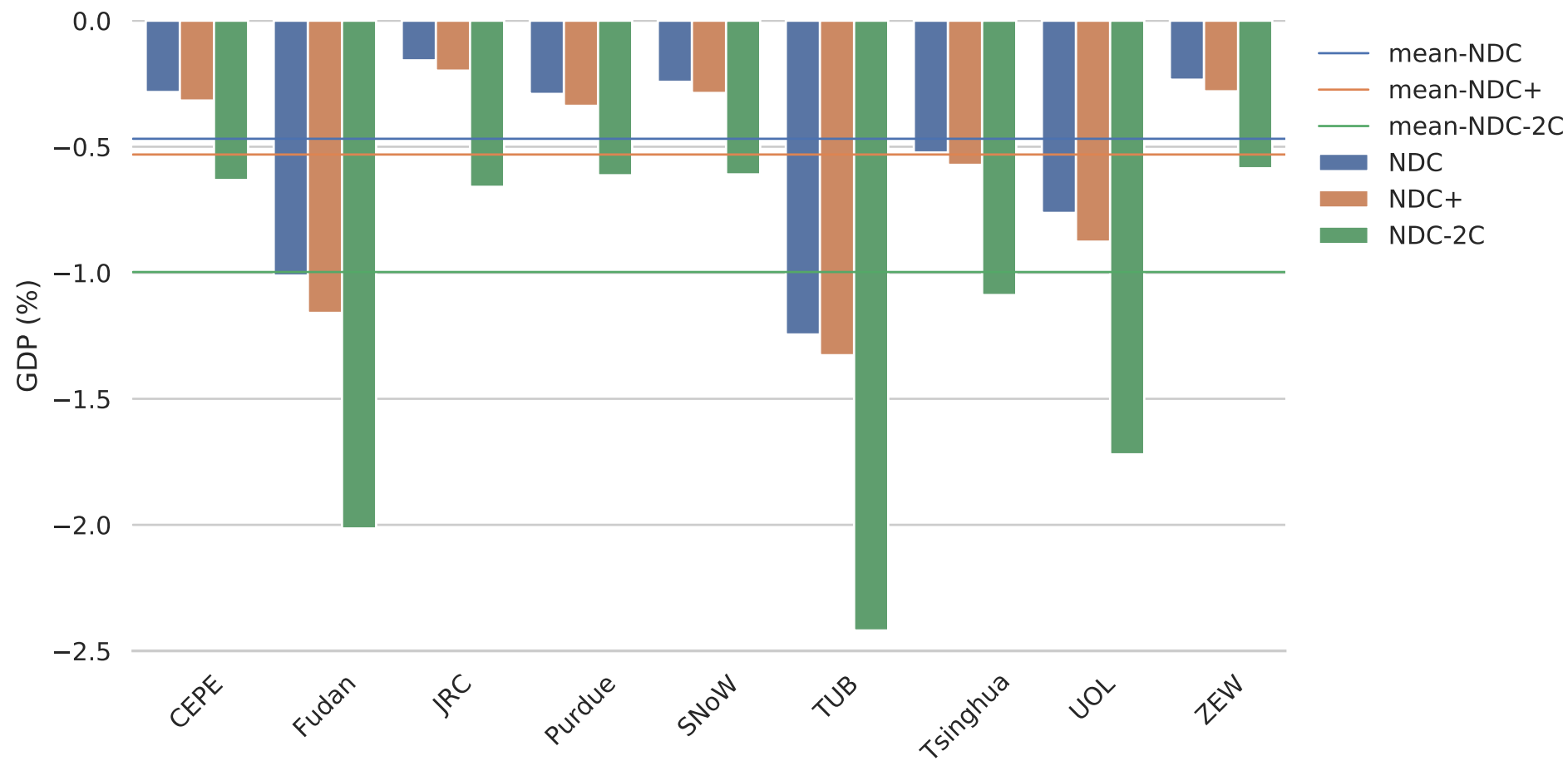
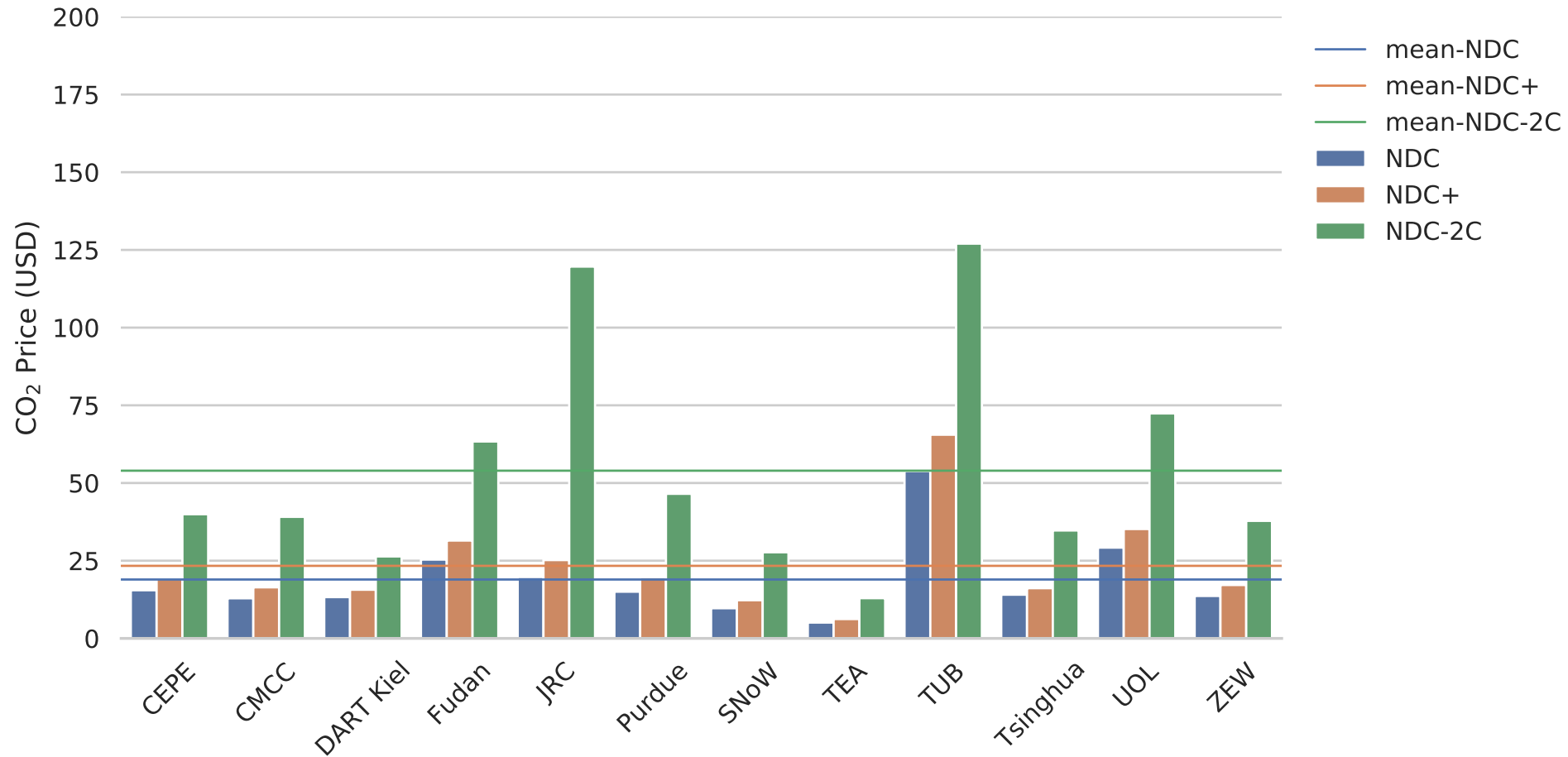IEO, REF

Global GDP

IEO, GLOBAL
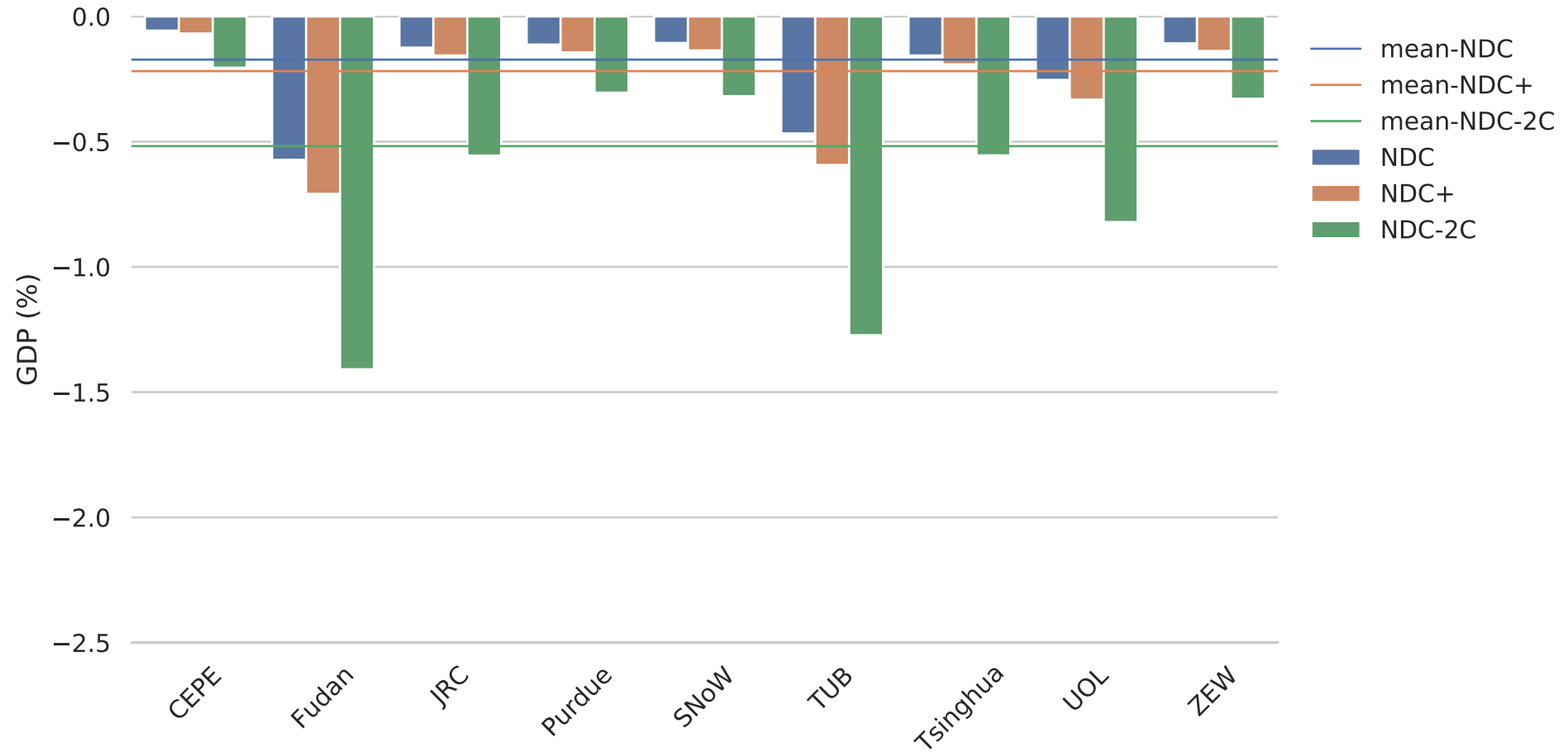
Global Average CO$_2$ Price

- Broad range from 10-70 $/tCO$_2$ under NDC, 26-180 $/tCO$_2$ under NDC-2C

- Underlying: KLEM nesting, elasticities, baseline CO$_2$ prices

Global Average CO$_2$ Price

IEO, GLOBAL

- Global cost savings between scenarios reflected in cross-region differences of CO$_2$ prices and abatement potential
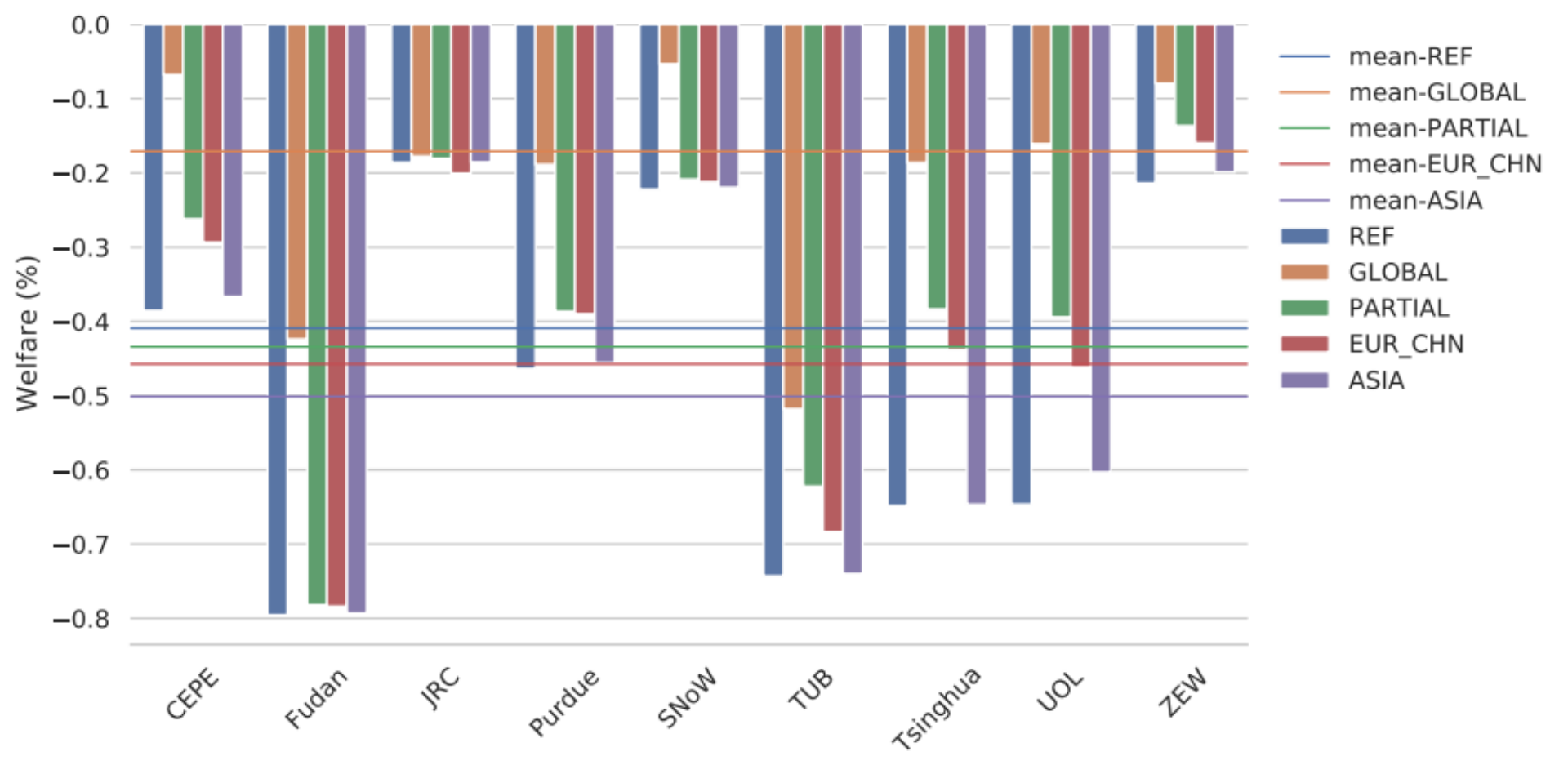
Baseline

- IEO
- WEO

Ambition

- NDC
- NDC+
- NDC-2C

Cooperation

- REF
- GLOBAL
- PARTIAL
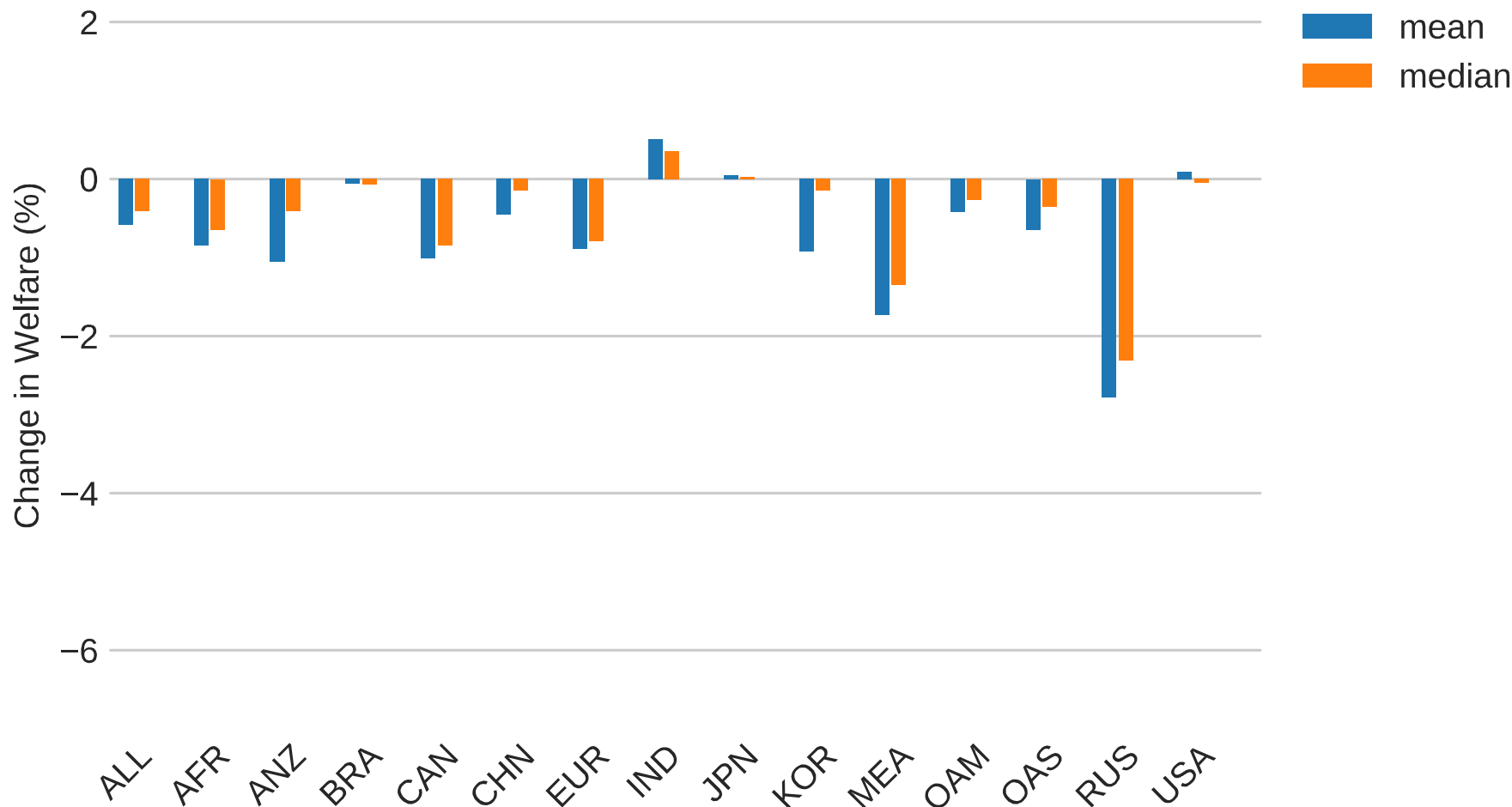- EUR_CHN
- ASIA

Global Welfare

Thank You!

APPENDIX

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More detailed (regional) comparison along scenario dimensions

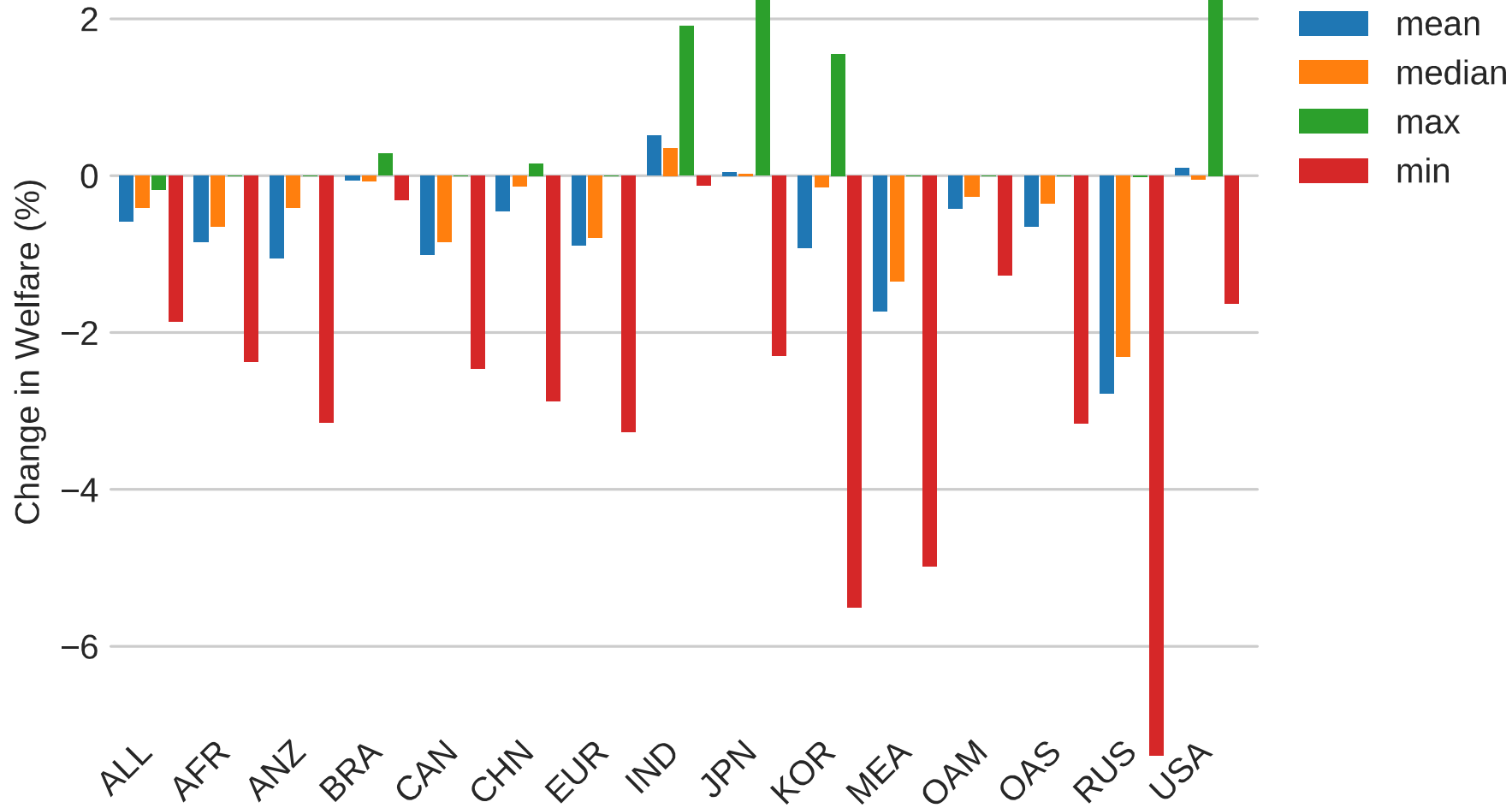| Baseline	Ambition	Cooperation
- IEO	- NDC	- REF
- WEO	- NDC+	- GLOBAL
	- NDC-2C	- PARTIAL
		- EUR_CHN
		- ASIA

Regional Welfare

- IND: relatively low reduction target compared to other emitters

- MEA and RUS: decline in CRU (OIL) and GAS prices
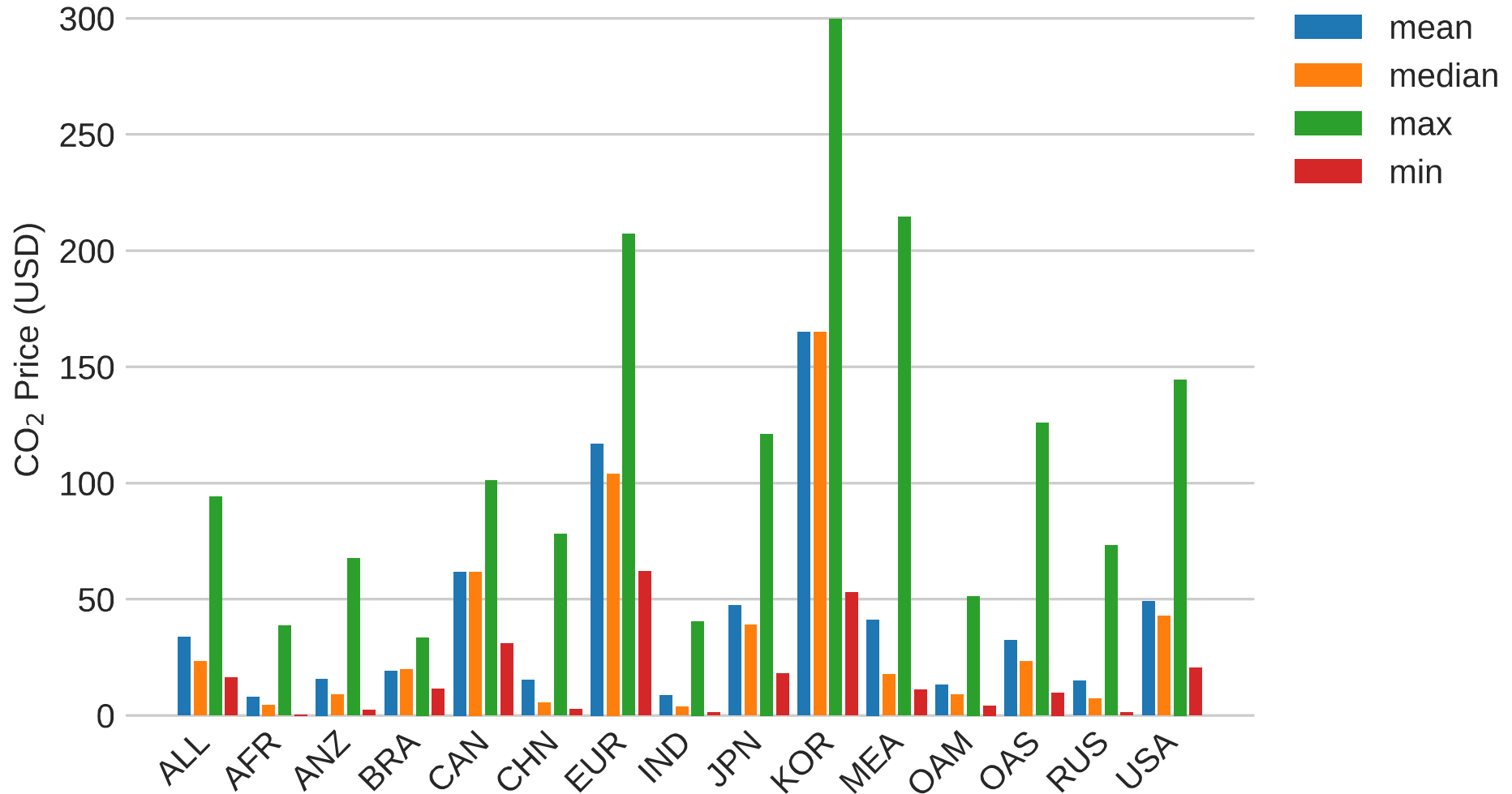 (importance of fuel supply elasticities for CRU, GAS, and COAL)

Regional Welfare

IEO, NDC, REF

Change in Welfare (%)

Legend: mean, median, max, min

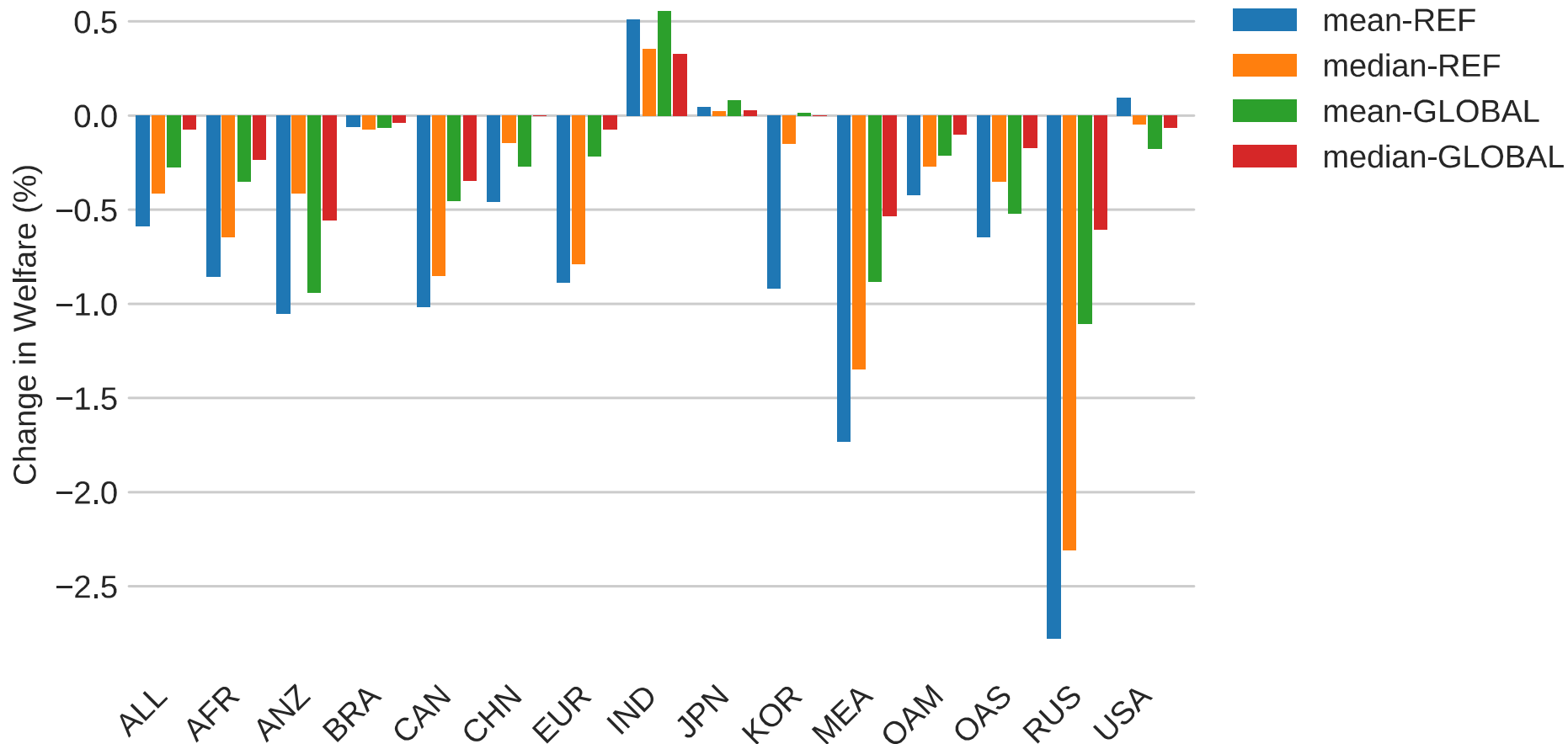- MACs and ToT changes as key welfare drivers

Regional CO$_2$ Prices
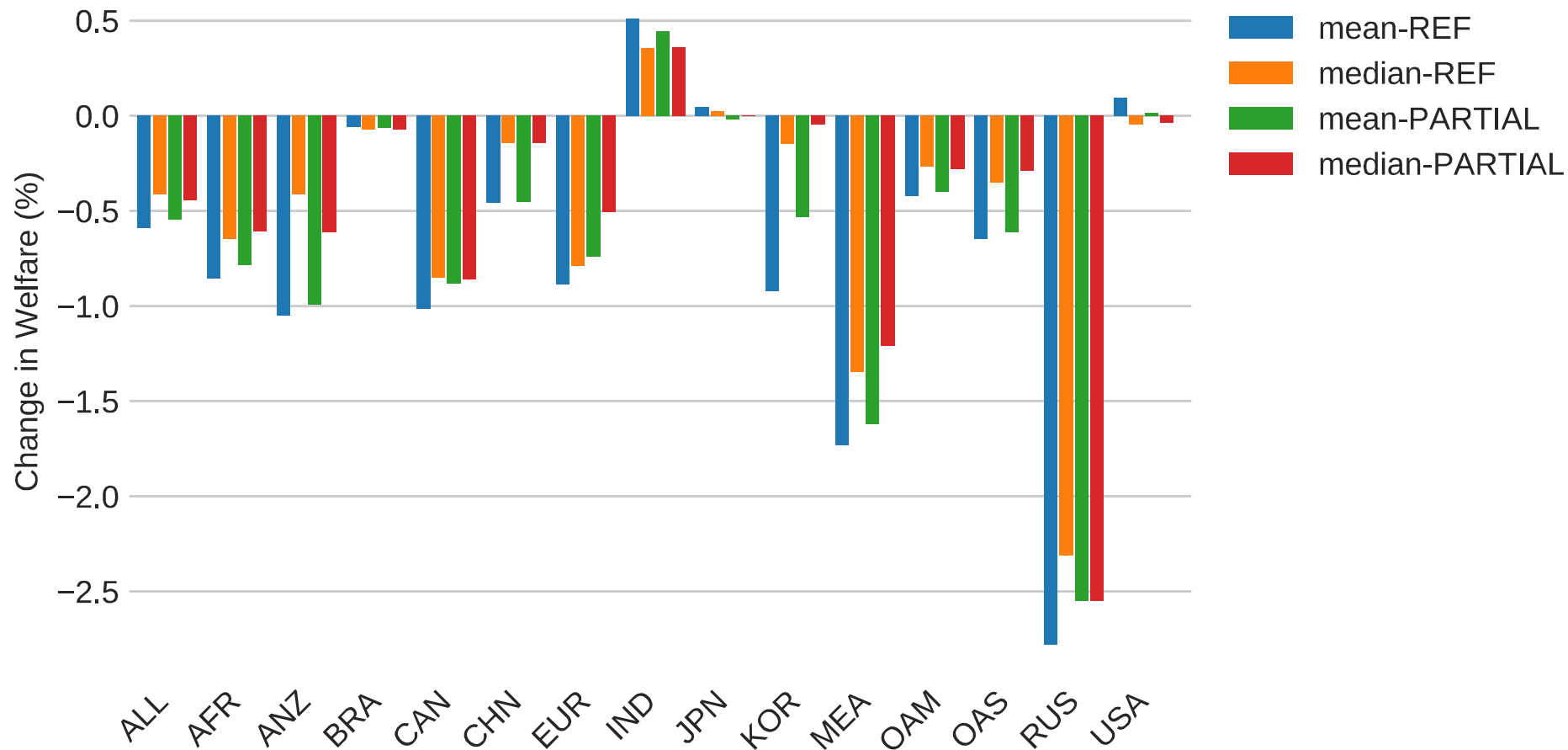
IEO, NDC, REF

Dito

Regional Welfare – REF, GLOBAL

- Unambiguous: Welfare gains on CO_2 market (CO_2 prices and abatement potential; MACs)

- Ambiguous: ToT on fuel markets (incidence shift from OIL, GAS to COAL) and non-fuel markets
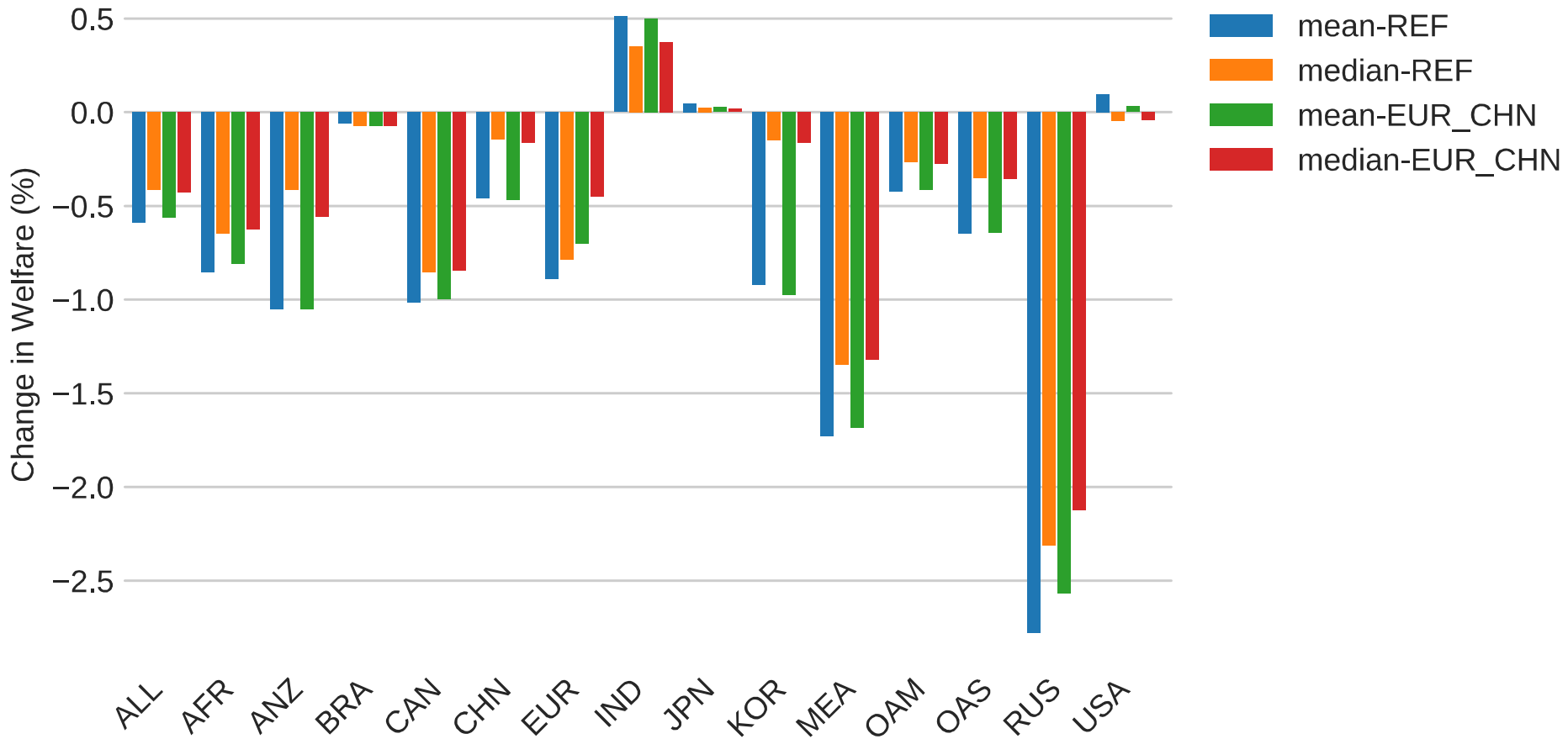
Regional Welfare – REF, PARTIAL

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

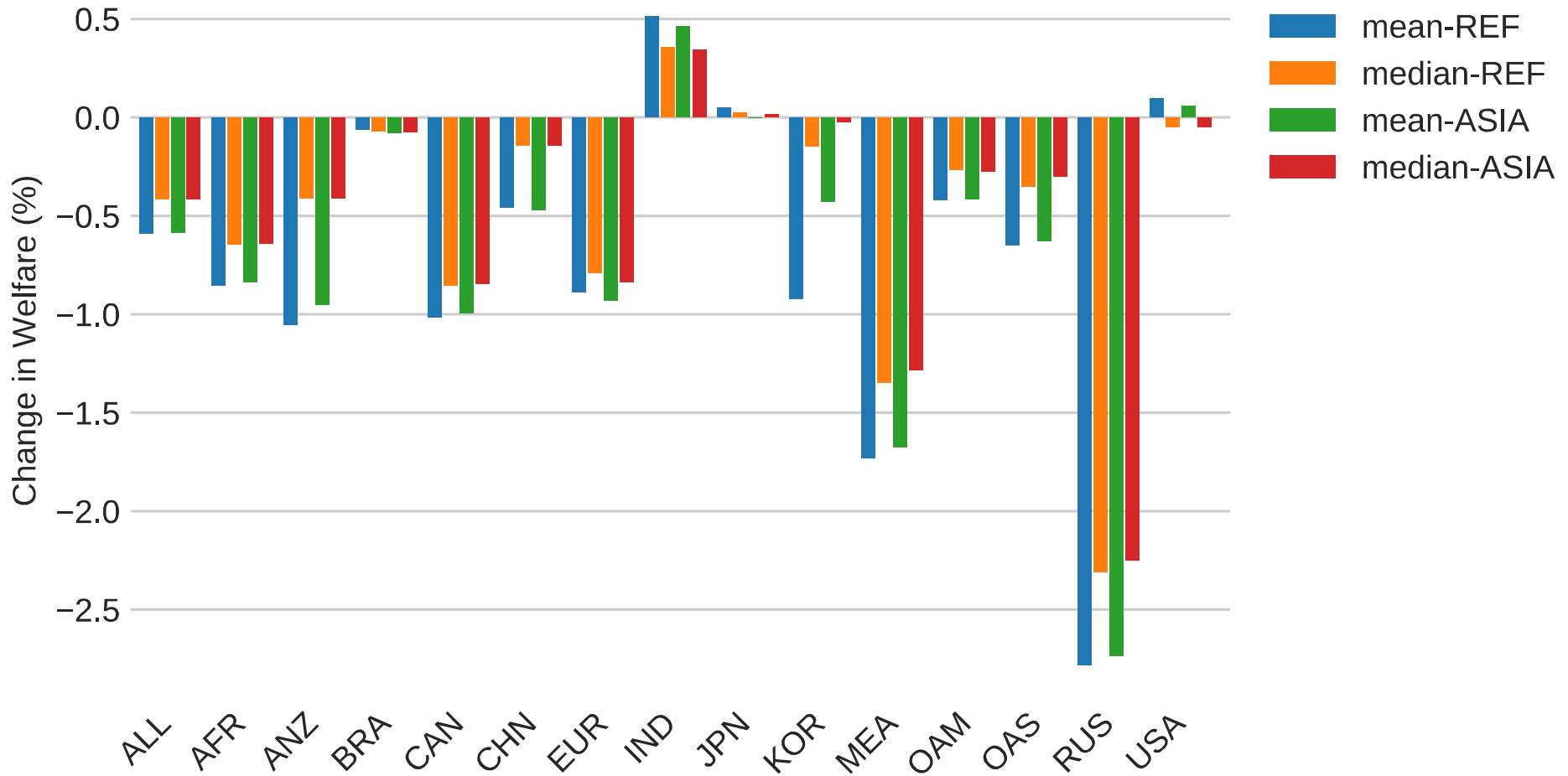Dito

Regional Welfare – REF, EUR_CHN

IEO, NDC

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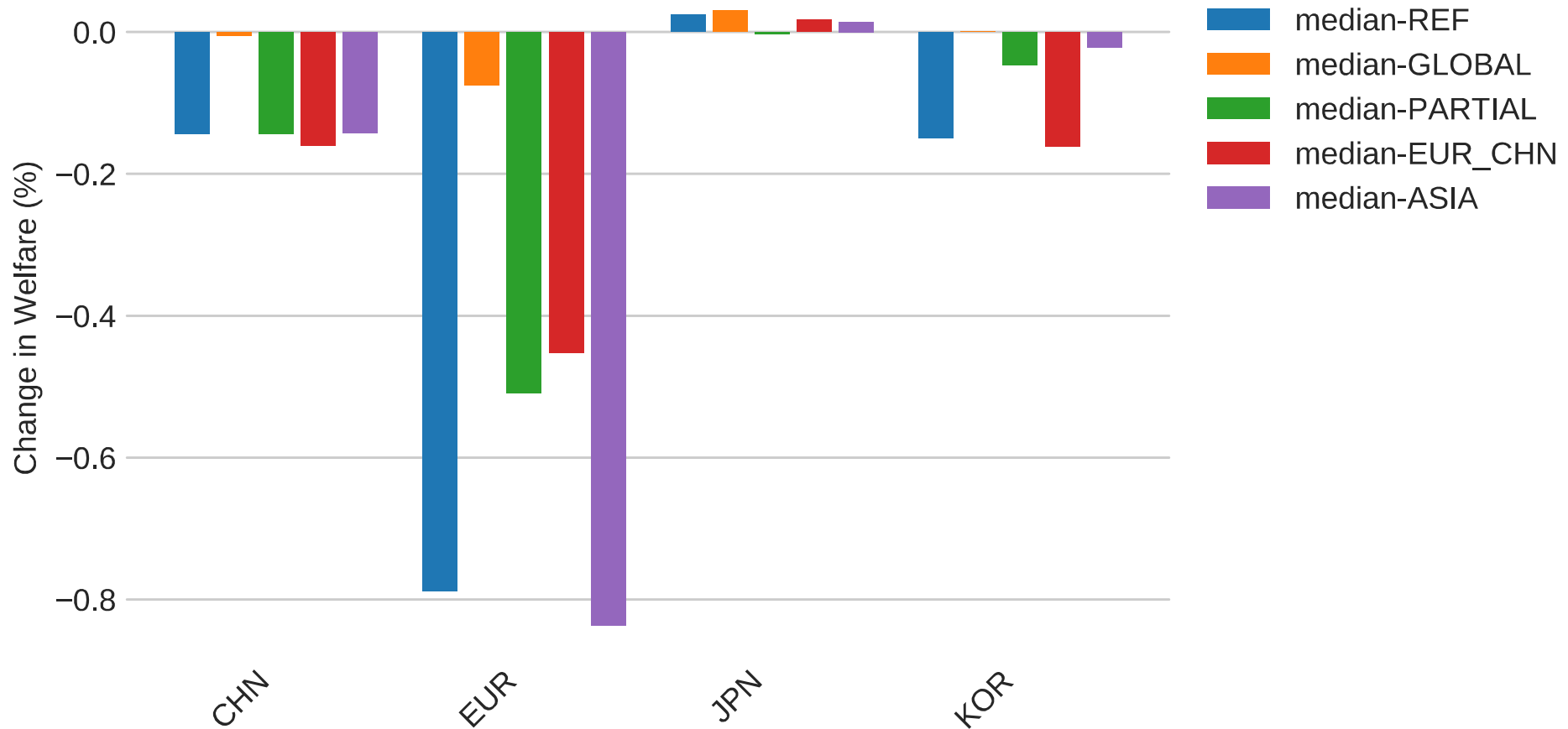
Dito

Regional Welfare – REF, ASIA

IEO, NDC

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

Dito

Regional Welfare – "Clubbers"

Change in Welfare (%)

Legend:
- median-REF
- median-GLOBAL
- median-PARTIAL
- median-EUR_CHN
- median-ASIA

X-axis: CHN, EUR, JPN, KOR

- CHN rather indifferent about EIT trading (direct gains from CO_2 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
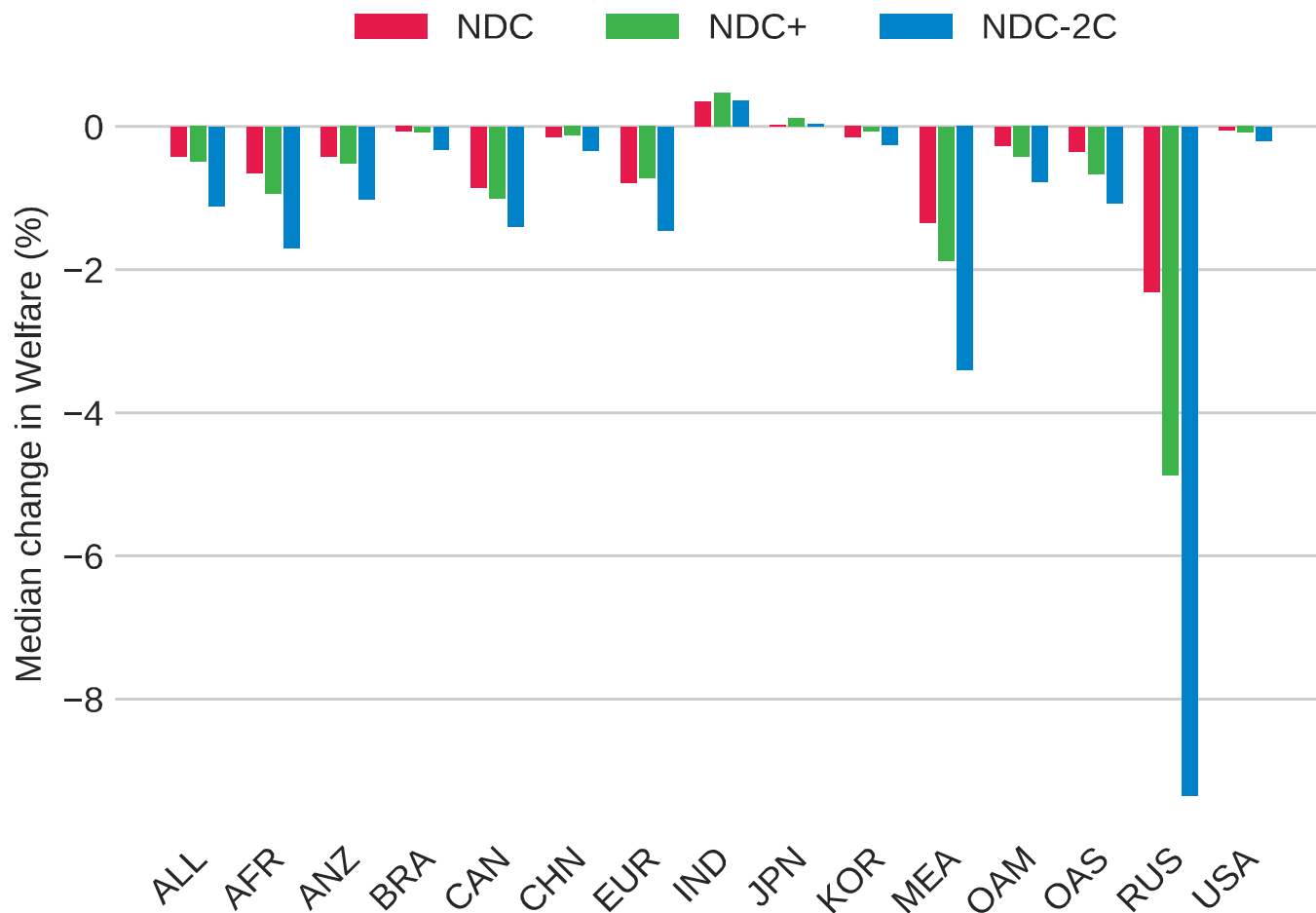
Dito

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)

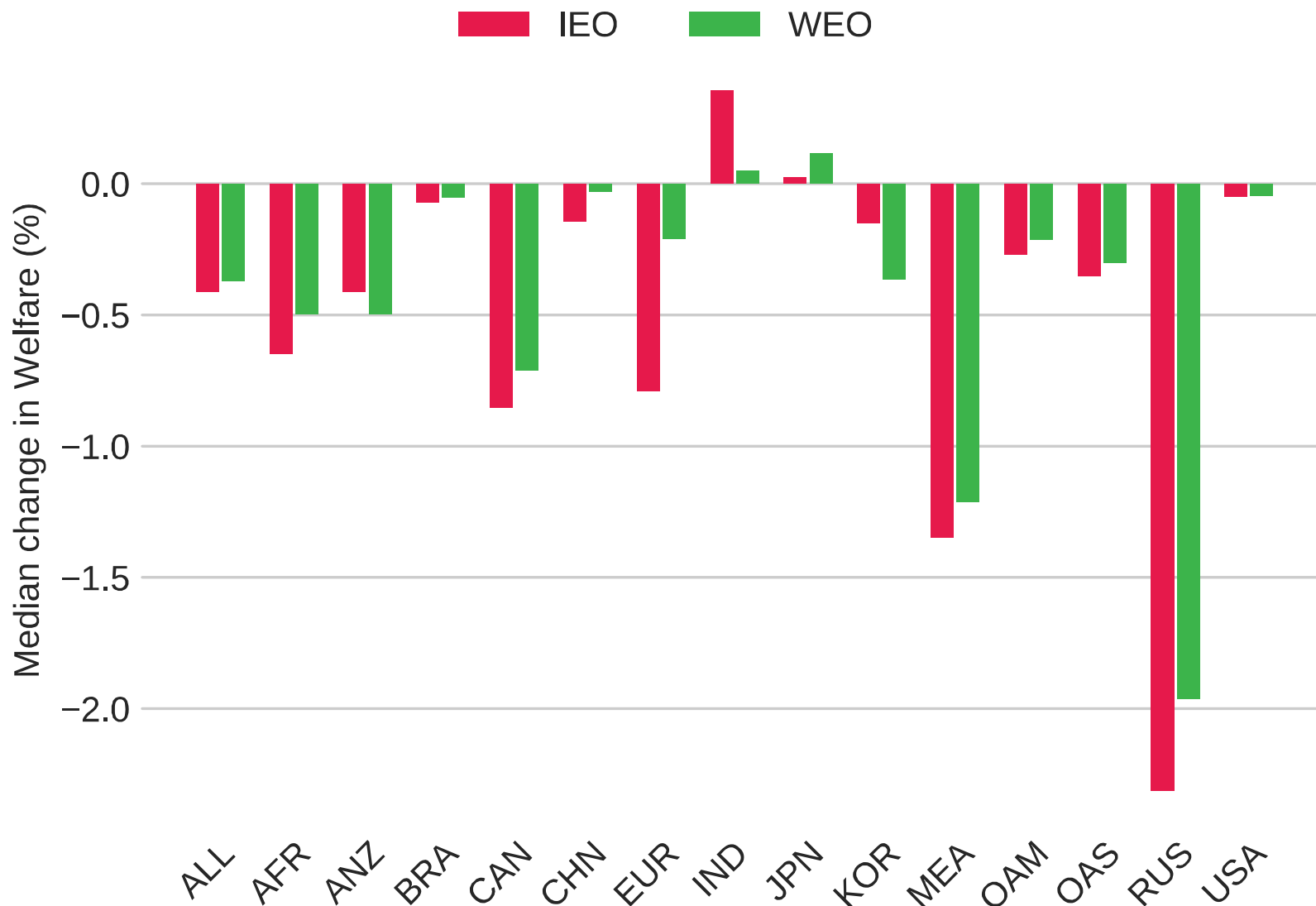Dito

Baseline

- IEO
- WEO

Ambition

- NDC
- NDC+
- NDC-2C

Cooperation

- REF
- GLOBAL
- PARTIAL
- EUR_CHN
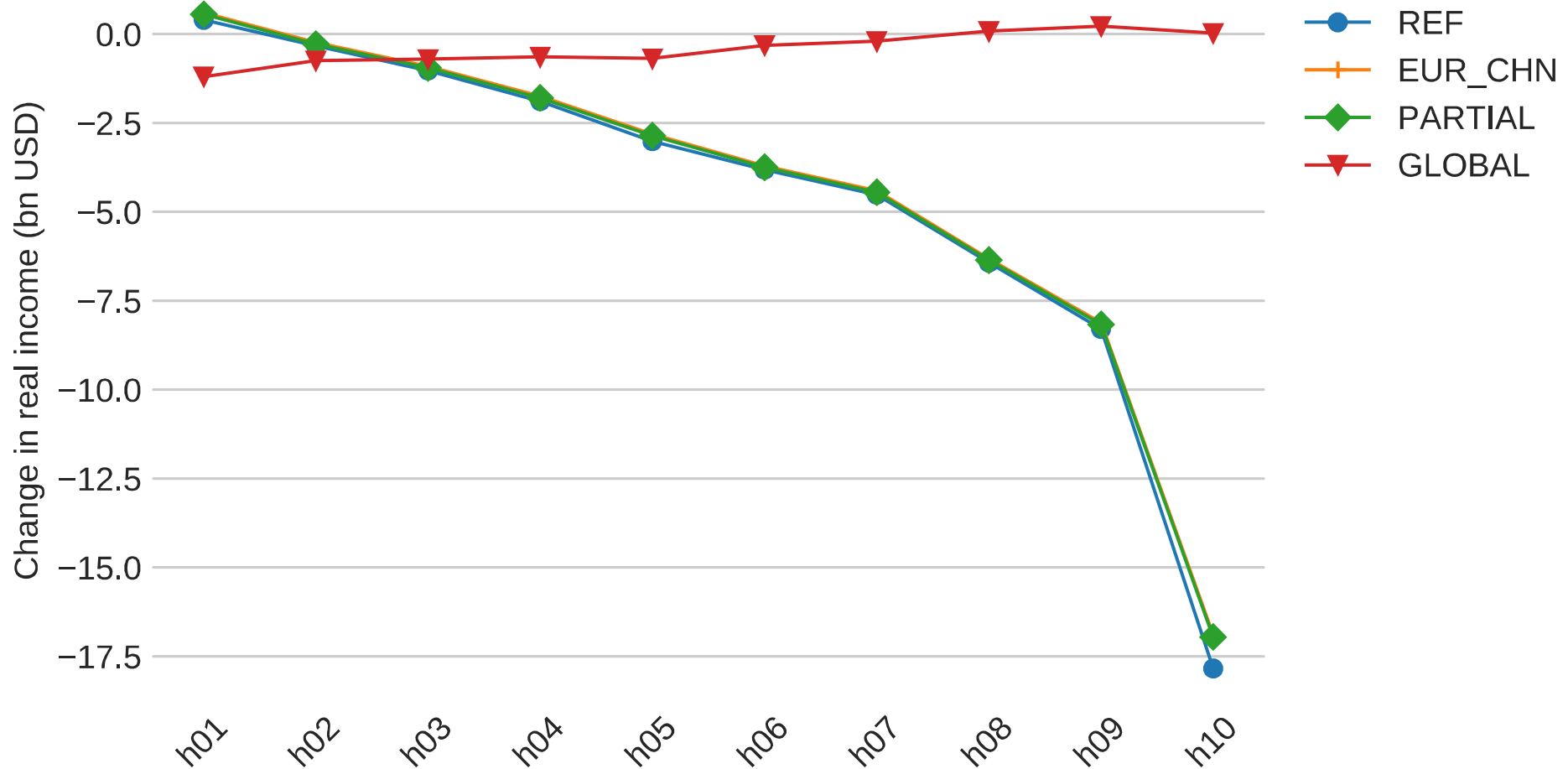- ASIA

Regional Welfare

- Differences in translated NDCs and baseline assumptions (MACs)

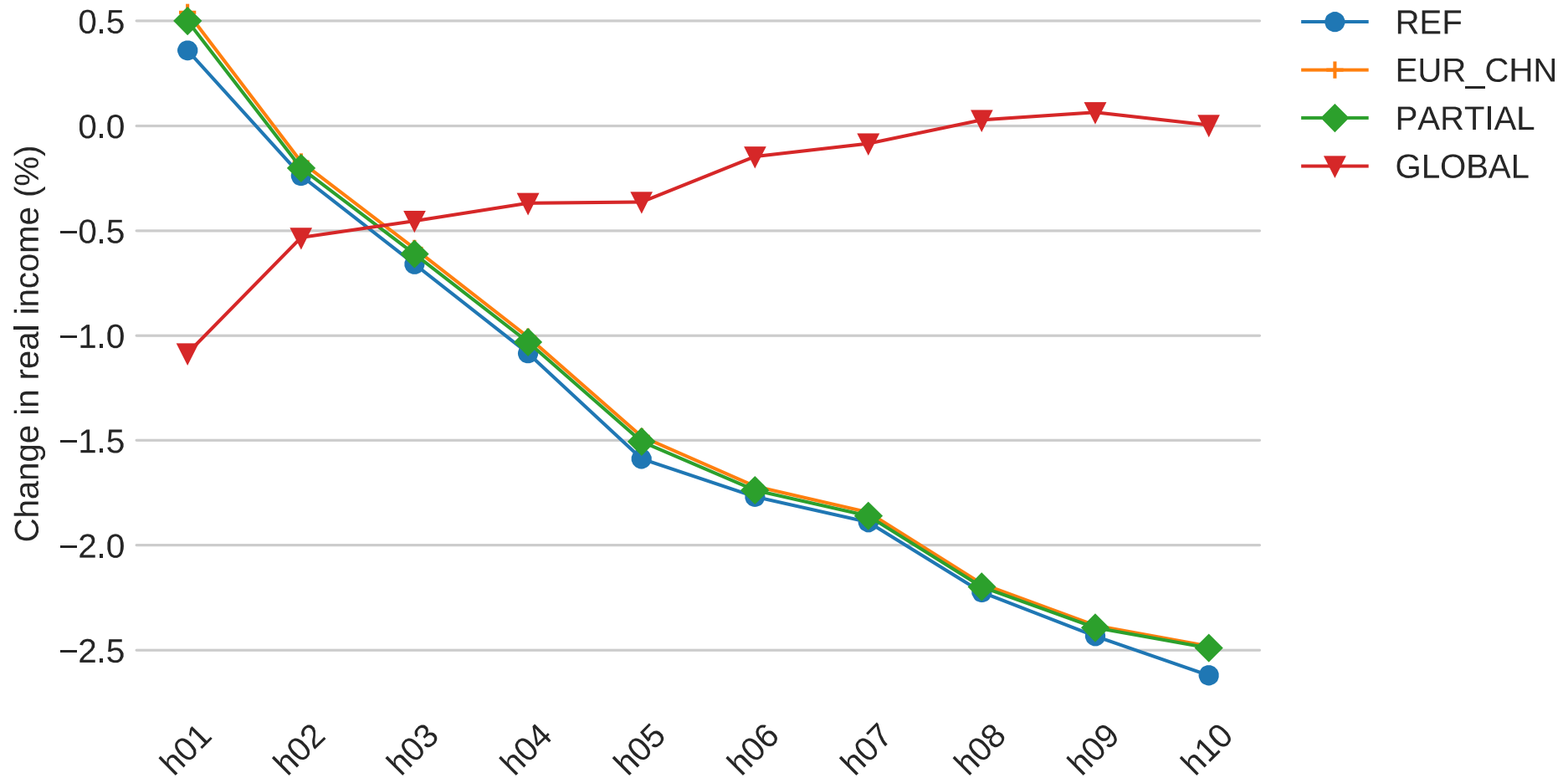# Household incidence analysis
–
Illustrative results
for
Germany

Welfare – USD

- Specific setup here: Transfers adjust to keep government expenditure constant
- GLOBAL: Effect of transfers outweighs CO_2 revenue redistribution

Welfare – %

Y-axis: Change in real income (%)

X-axis: h01, h02, h03, h04, h05, h06, h07, h08, h09, h10

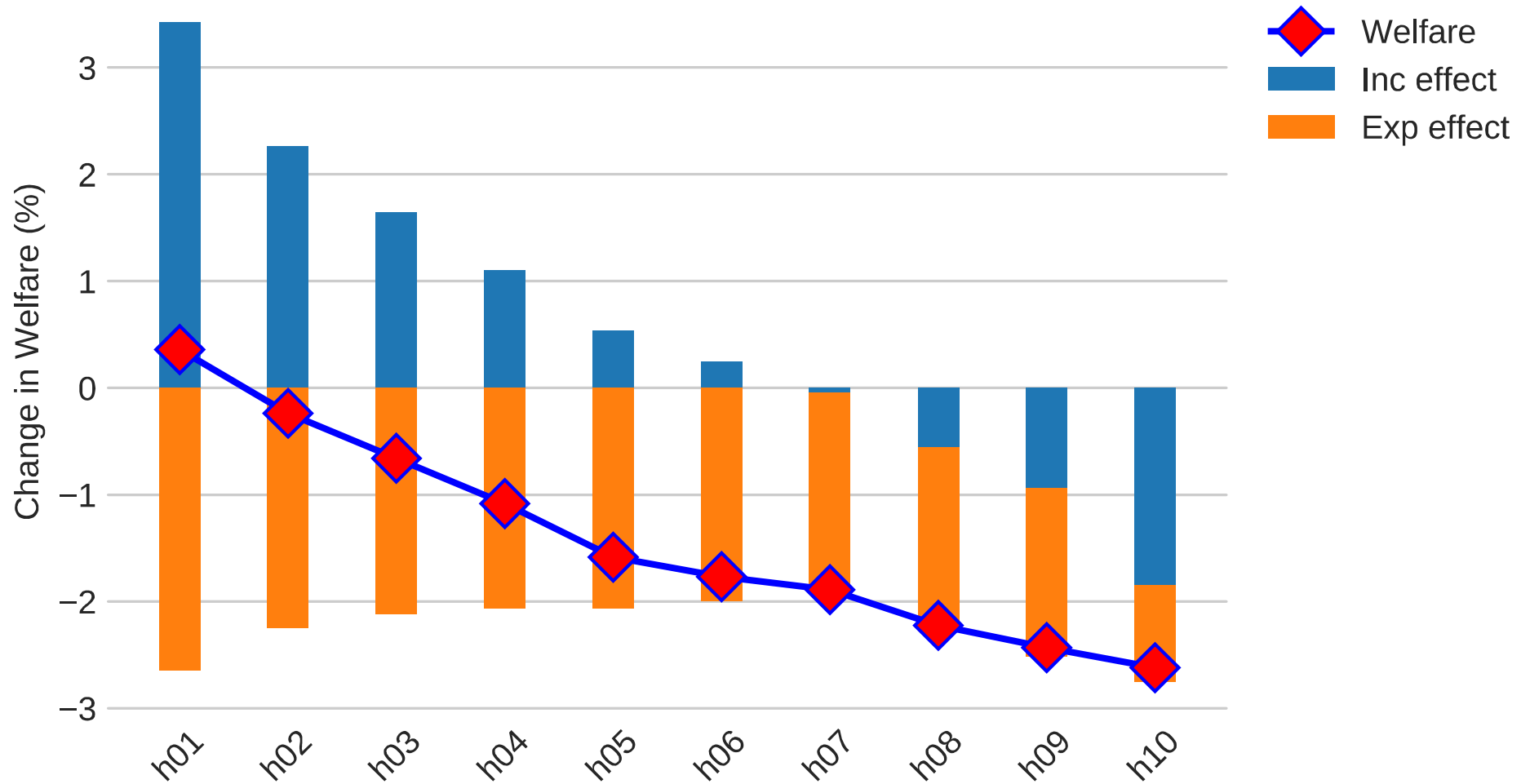**Legend:** REF, EUR_CHN, PARTIAL, GLOBAL

- Specific setup here: Transfers adjust to keep government expenditure constant
- GLOBAL: Effect of transfers outweighs CO_2 revenue redistribution

Income and Expenditure Effects

Social Welfare – EDE