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Climate change impacts and market driven adaptation:

The costs of inaction including market rigidities

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EUROPEAN COMMISSION
European Research Area

SEVENTH FRAMEWORK PROGRAMME

GLOBAL-IQ final Conference
Brussels, 17th June 2014

Outline

- Objectives
- The model
- Climate change impact assessment
  - The impacts
  - Effects on world and regional GDP
  - Impact decomposition
- Limiting market adaptation
- Reduced form damage functions

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Objectives

Climate change as a global challenge → what is its economic relevance?

Investigation tool: recursive-dynamic CGE model → allows for endogenous price formation and market autonomous response to economic shocks

Impacts are assessed in three RCP's (2.6, 6.0, and 8.5) as reference cases to extract then reduced form climate change damage functions

Moreover, firstly "full market-driven adaptation" is assumed, then limits or frictions in market adjustments is introduced.

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The model: ICES

Recursive dynamic computable general equilibrium (CGE) model

Multi-country, multi-sector model. Endogenous prices allocate resources → track feedback between "markets" and the macro economic context triggered by initial impacts

- Based on the GTAP 8 database (Narayanan et al. 2012)
- Simulation period: 2007-2050 in one-year time steps
- Multi-country (25 countries/regions)
- Multi-sector model with international trade (19 sectors)
- CO_2 emissions from fossil fuel combustion
- Renewable energy production (solar, wind, hydro)

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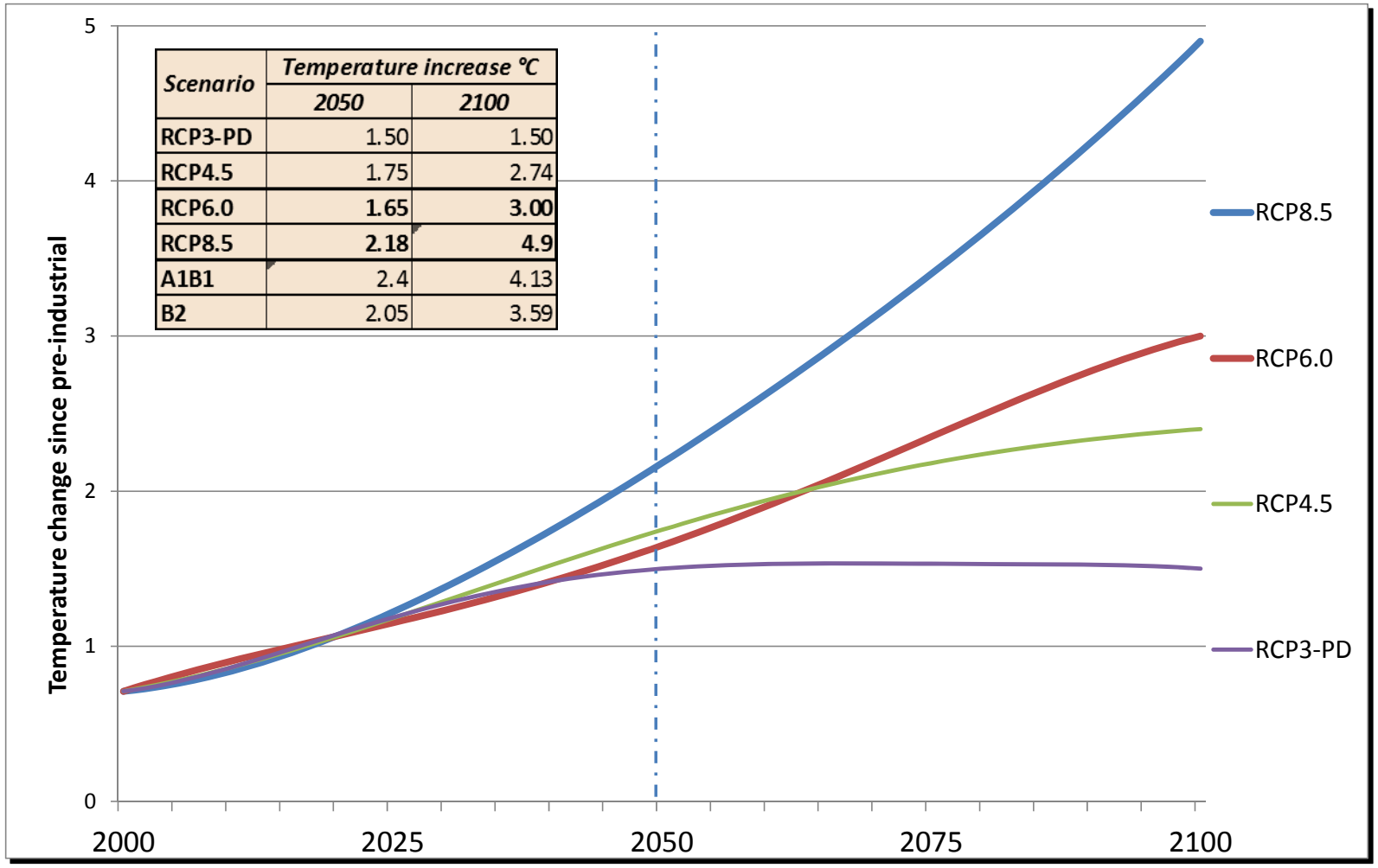
Temperature increases in different RCPs



Scenario	Temperature increase °C	
	2050	2100
RCP3-PD	1.50	1.50
RCP4.5	1.75	2.74
RCP6.0	1.65	3.00
RCP8.5	2.18	4.9
A1B1	2.4	4.13
B2	2.05	3.59

Sources: **IIASA GGI Scenario database (Version 2.0.1)**
Rogelj et al. (2012)

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Climate change impacts assessed and modelling strategy

Agriculture	(Δ crop yields) Δ land productivity
Ecosystems	Δ services from physical capital stock
Energy Demand	Δ residential demand of oil, gas, electricity
Fishery	Δ natural resource stock used by the fishing industry
Forestry	Δ in productivity of natural resource stock used by the wood processing sector
Health	Δ labour productivity as well as private and public expenditures
Sea-Level Rise	Δ in land and physical capital stock
Tourism	Δ in households' demand for recreational services (part of market services) and in expenditure

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Climate change impacts: Sources

CC Impacts	Sources	Available Scenarios
Agriculture	PIK - LPJmL ISIP-MIP runs	RCPs 2.6, 6.0, and 8.5
Health	Tol (2002)	Reduced form
Sea level Rise	Diva model - Vafeidis et. al (2008) CLIMATECOST project	A1B
Tourism	Hamburg Tourism Model - Bigano et. al (2007) CLIMATECOST project	A1, B2
Energy demand	POLES model - Criqui (2001), Criqui et. al (2009) CLIMATECOST project	A1B
Forestry	PIK - LPJmL Bondeau et. al (2007), Tiejten et al (2009) CLIMATECOT project	A1B
Fisheries	Cheung et. al (2010) SESAME project	A1B
Ecosystem	Warren et al (2006)	Reduced form

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Summary of scenarios

- Economic reference: SSP2

- Full Adaptation
  - Climate change impact assessment
    - Climate change impacts (8)
    - RCPs: 2.6, 6.0 and 8.5
    - ➢ Impacts on world and regional GDP
    - ➢ Reduced-form damage functions

- Limited Adaptation

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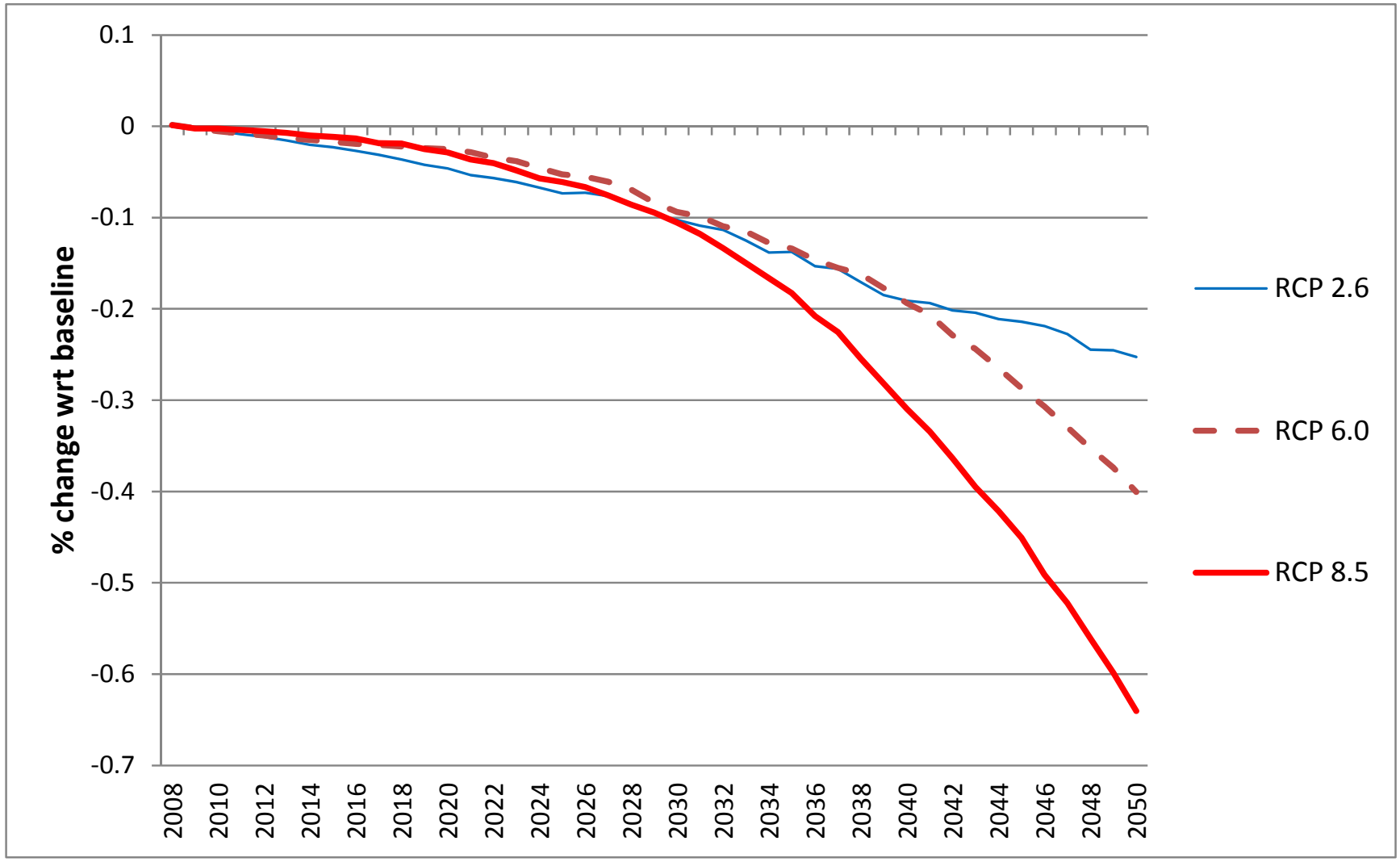
Climate Change Impact on Gross World Product



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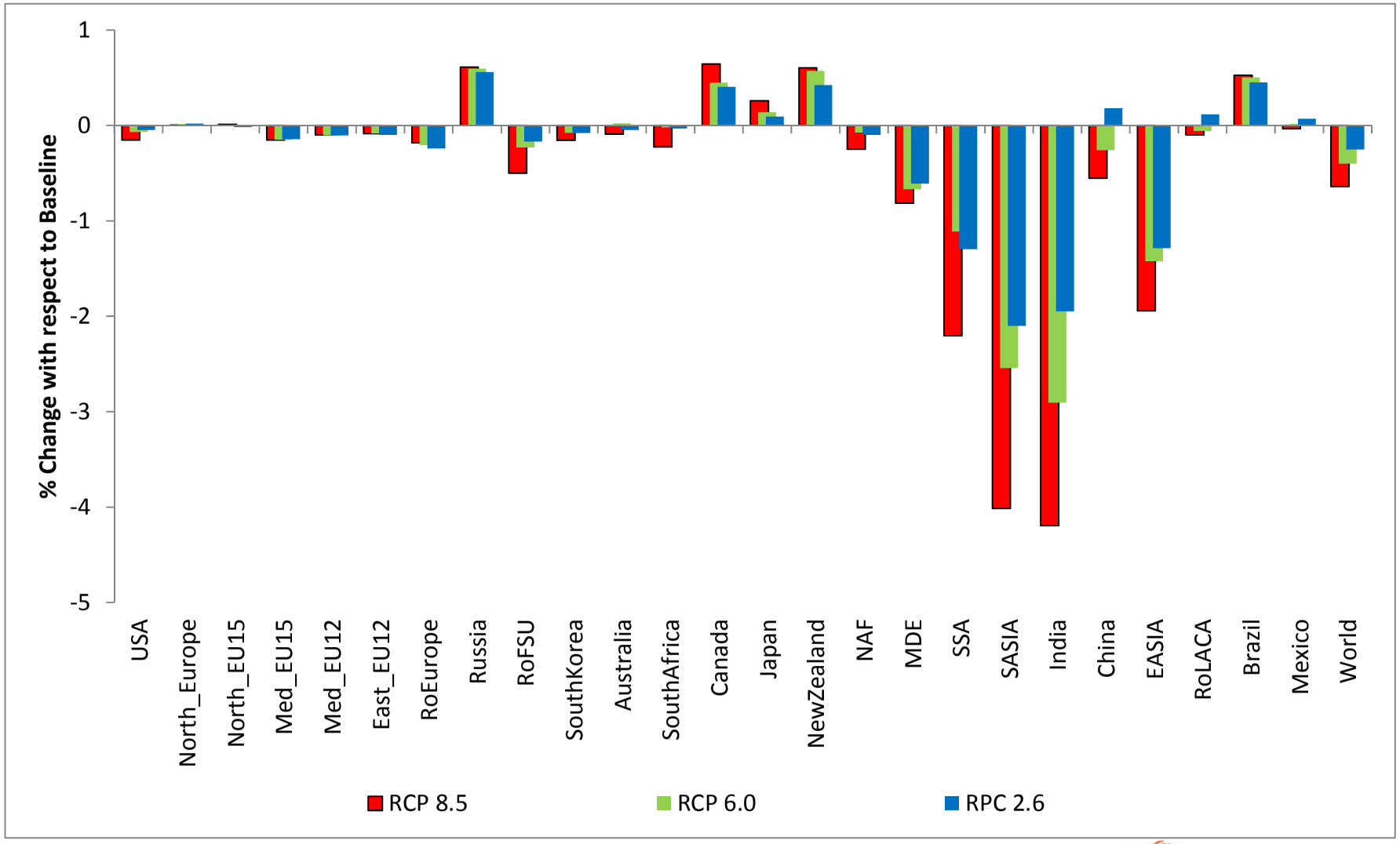
CC impacts on GDP in 2050 – regional breakdown



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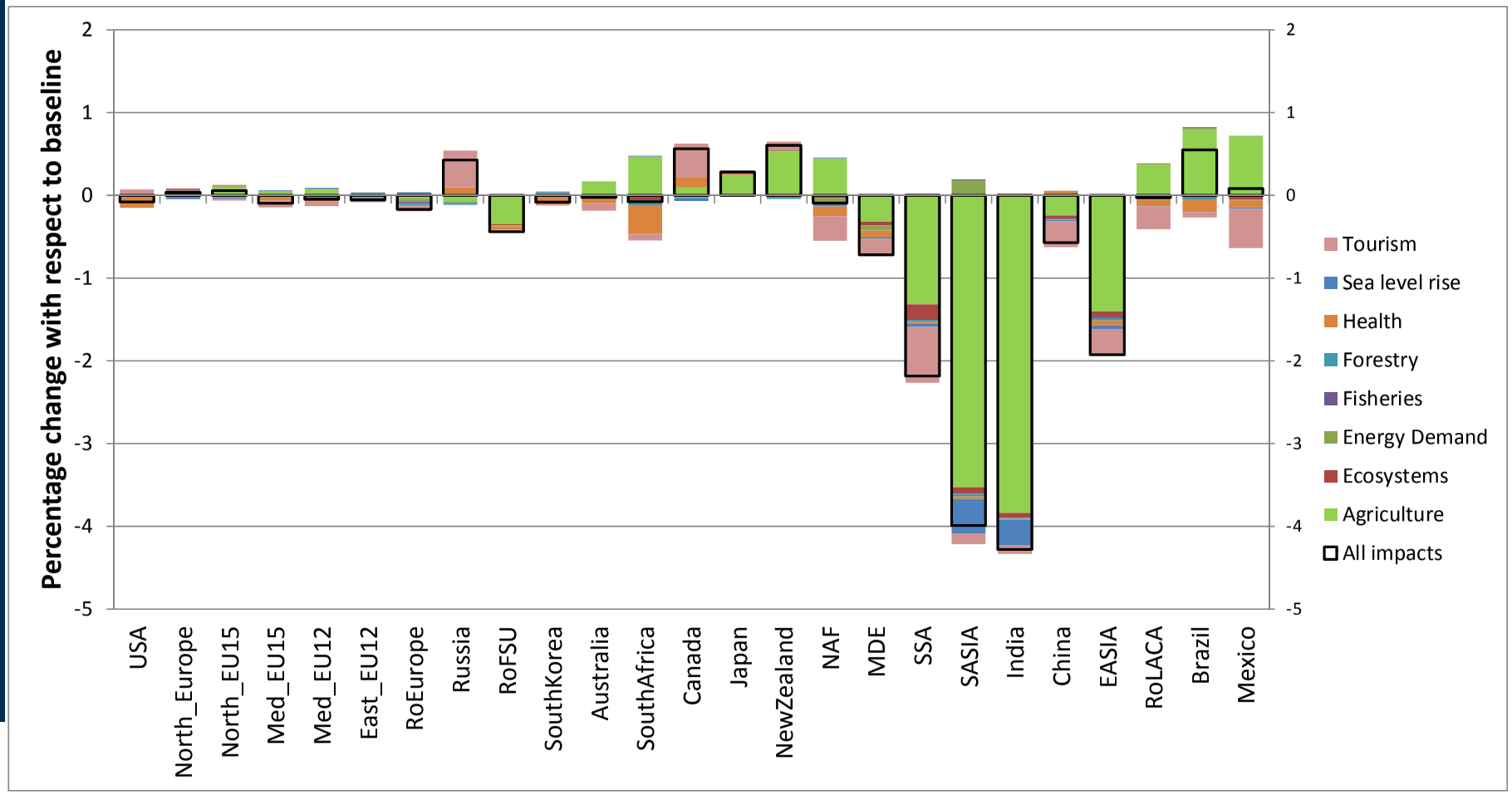
CC impacts on GDP in 2050 – decomposition RCP 8.5



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Introducing limited adaptation

- Set of simulations considering limited market-driven adaptation in three specific features (parameters) of the model:

  - Trade (*LA-TR*): reducing the model's flexibility to accommodate international trade flows.
  - Labor mobility (*LA-LM*): limiting workers mobility within sectors in each region.
  - Primary factor substitution (*LA-PFS*): decreasing the flexibility to combine production factors (labor, natural resources, land and capital-energy).

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ICES: Limited Adaptation scenarios

- Climate change impacts with RCP 2.6, 6.0 and 8.5
  - Trade (Armington elasticities reduced to 75%): *LA-TR*
  - Primary factor substitution (substitution elasticity reduced to 75%): *LA-PFS*
  - Limited labor mobility allowing for wage differences: *LA-LM*
  - All rigidities (TR, LM, PFS): *LA-AR*
  - ➢ Impacts on world and regional GDP

➢ We set the limited adaptation values for elasticities based on:

- ➢ Armington elasticities: ratio of mean elasticity to the lower end of the 68% confidence interval: $\mu/(\mu - 1\sigma)$.
- ➢ Factor substitution: ratio of short term to medium term elasticities.

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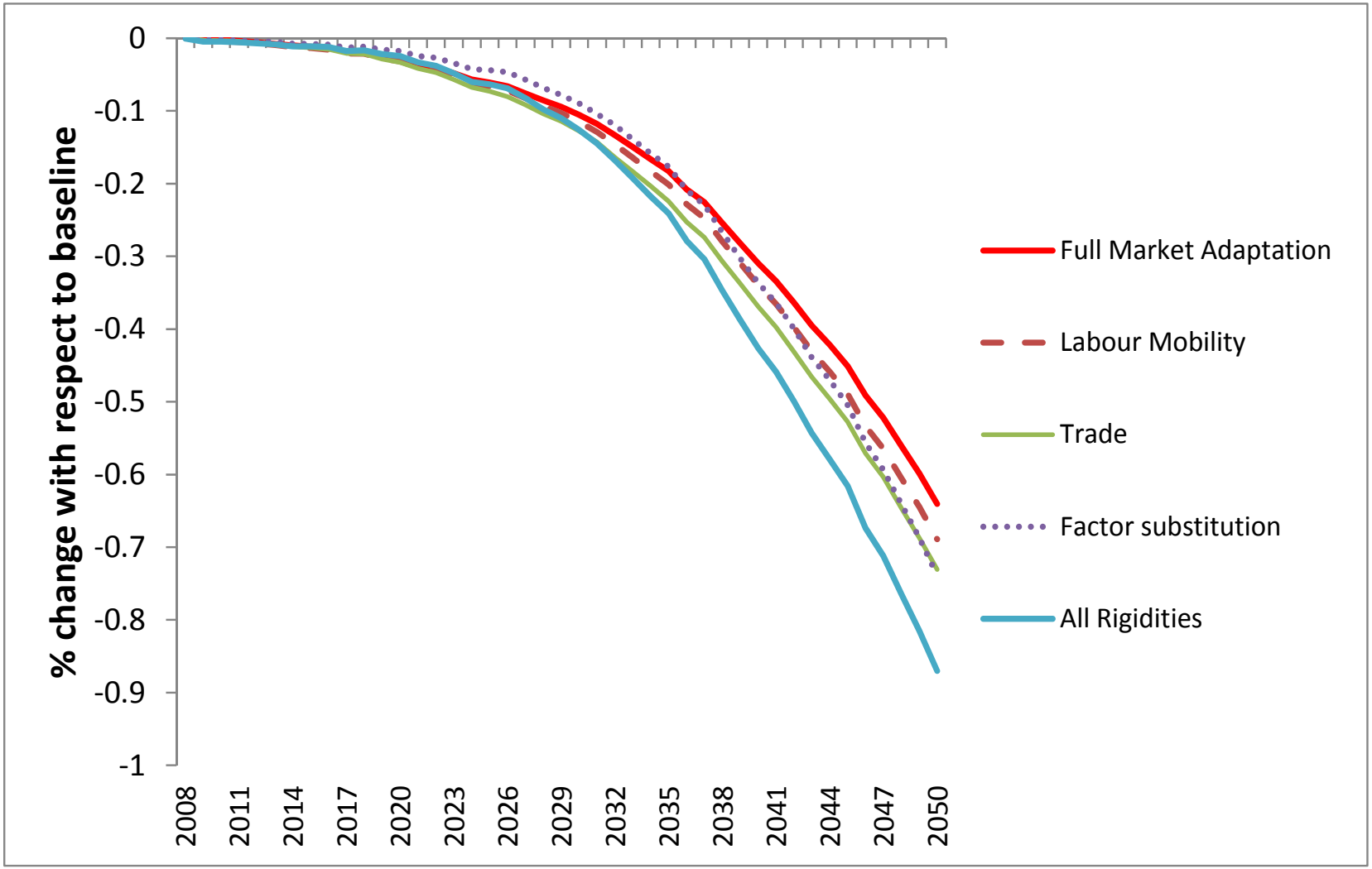
Climate change impacts on GWP for RCP 8.5



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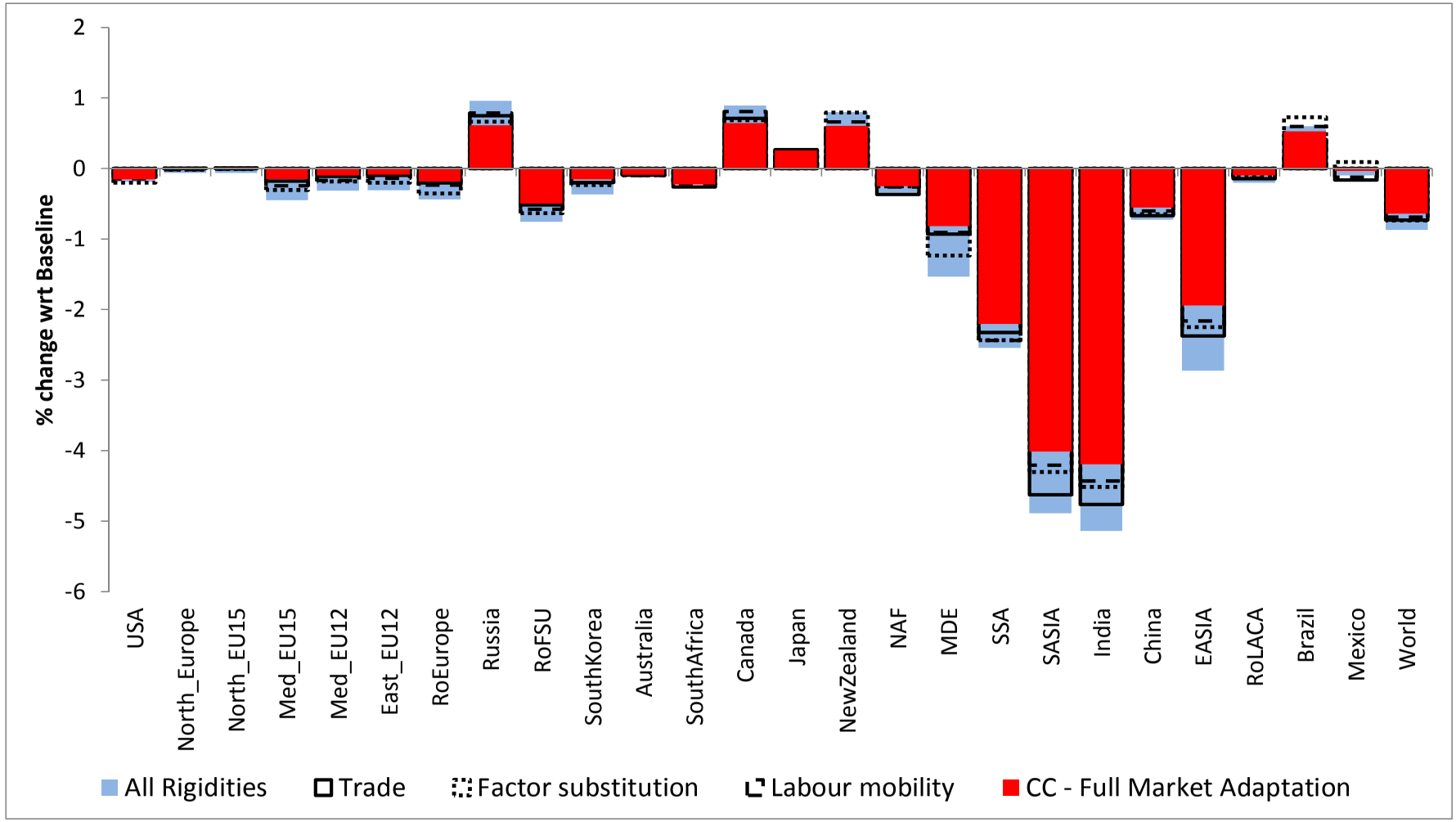
RCP 8.5 impacts on regional GDP with limited adaptation



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Reduced-form climate damage functions

•Using different RCPs to obtain also different (namely 3) temperature increases and therefore impacts and GDP effects in the same year.

•To “clean” or control for the social economic factors we selected as reference one single year (2050).

•Each pair (GDP cost, temperature increase) for each region account for ***market impacts***.

•We include a ***catastrophic damage*** component following Nordhaus and Boyer (2000) and Nordhaus (2007).

•The ***total damage*** is the sum or *market* plus *catastrophic* damages which we finally use to extrapolate the reduced-form climate change damage function.

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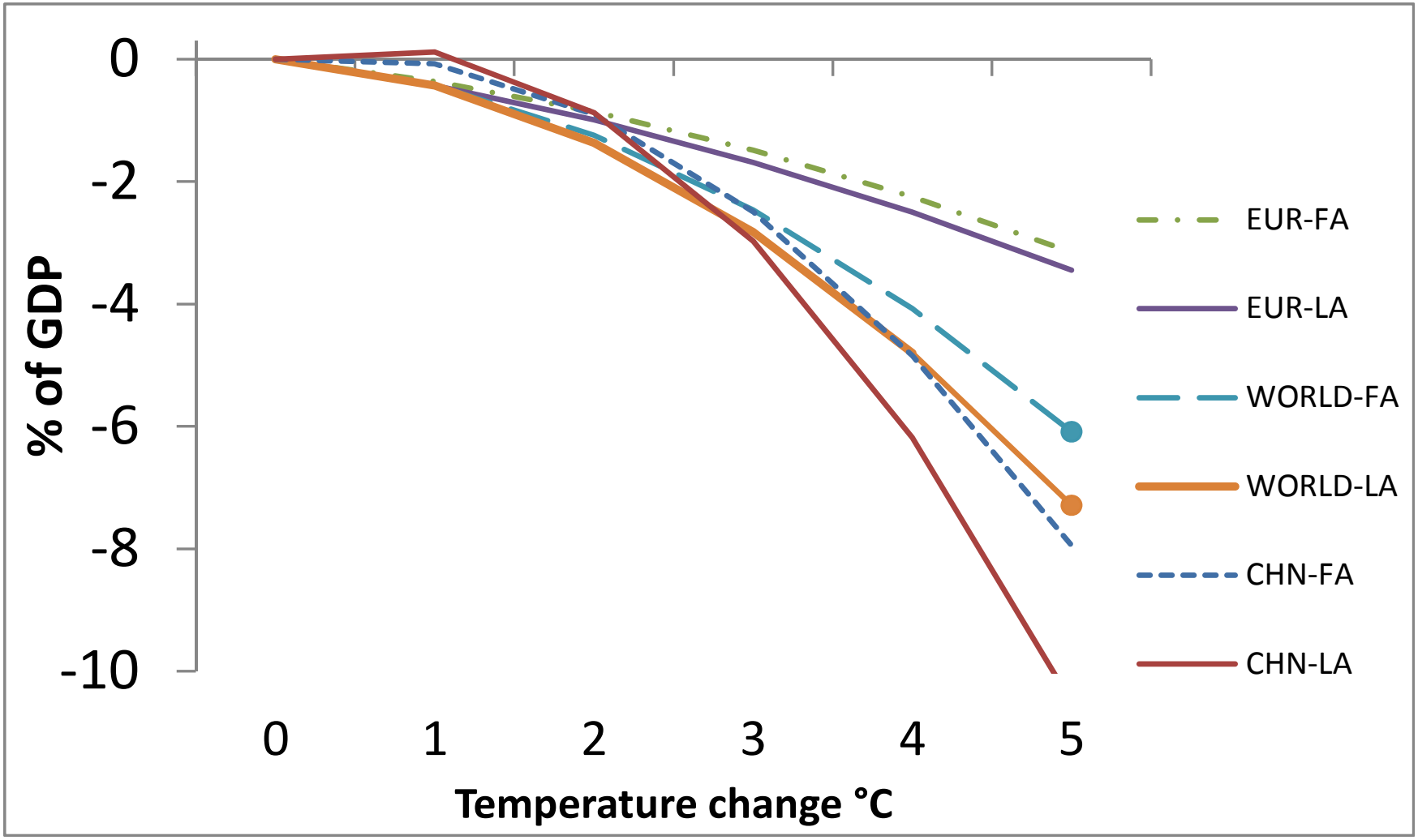
Reduced-forms with Full (FA) and Limited adaptation (LA)



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Conclusions (1)

- In 2050 total costs roughly amount to 0.64% of GWP in RCP 8.5 (2.5C increase).
- Aggregate figures hide important regional asymmetries and a differentiation in regional exposure, sensitivity and adaptive capacity.
- Higher vulnerability of developing countries to climate change impacts. (South Asia and India lose more than 4% of their GDP, Eastern Asia and Sub Saharan Africa losing roughly 2% of their GDP in 2050 for RCP 8.5).
- Introducing rigidities in impact assessment reveals an increase of climate change costs. GWP losses rise roughly to 0.87%.
- A major driver of these peaking costs is the lower degree of substitution across primary factors, pushing alone losses to more than 0.73% of Global GDP in 2050.

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Conclusions (2)

- Relatively minor deviations from the basic parameterization of the model are able to increase impacts by roughly 30% at the global level.

- Considering reduced-form damage functions, limited adaptation results in a higher damage for the world in particular for higher temperatures (20% higher than with full adaptation at a temperature of 5° C).

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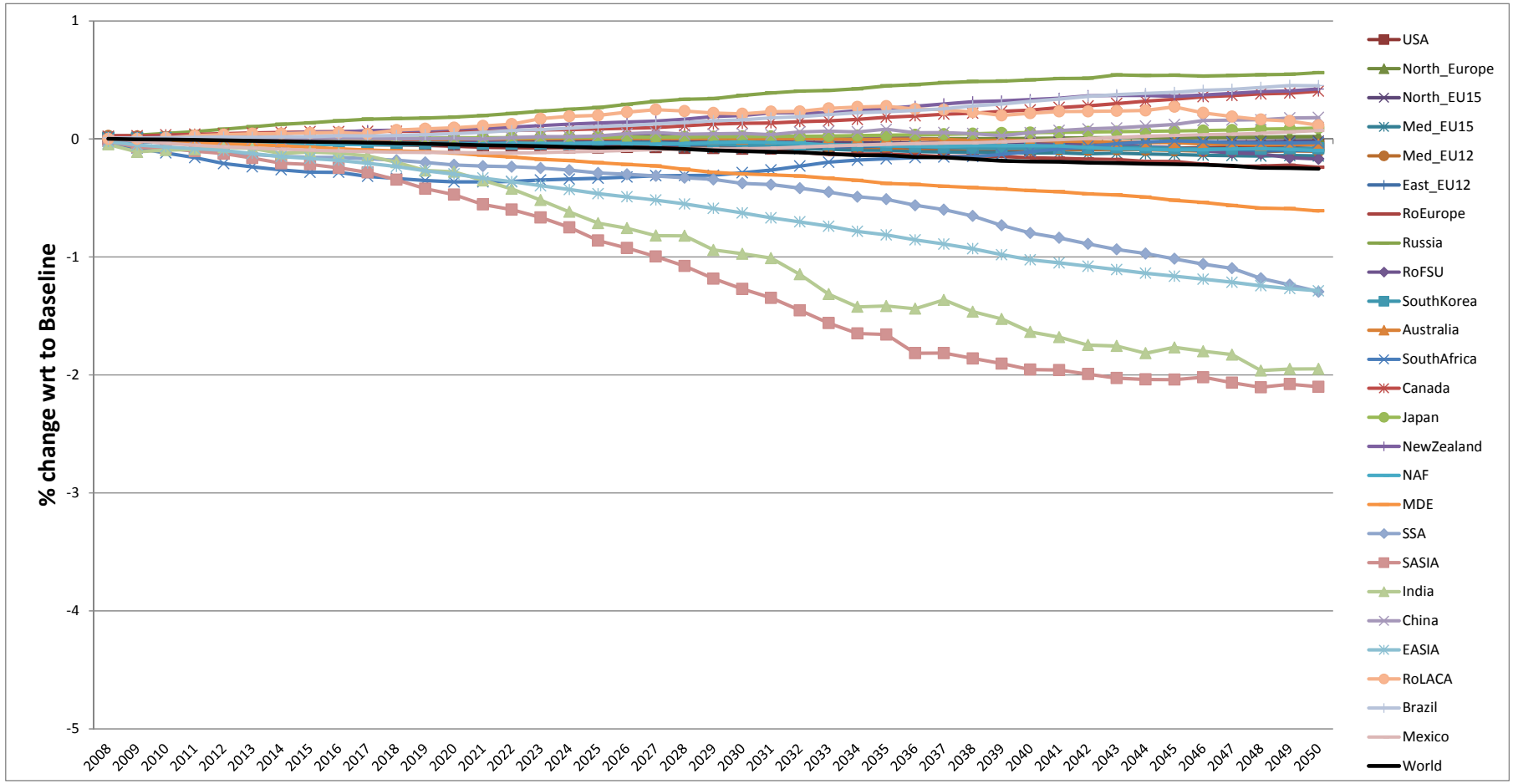
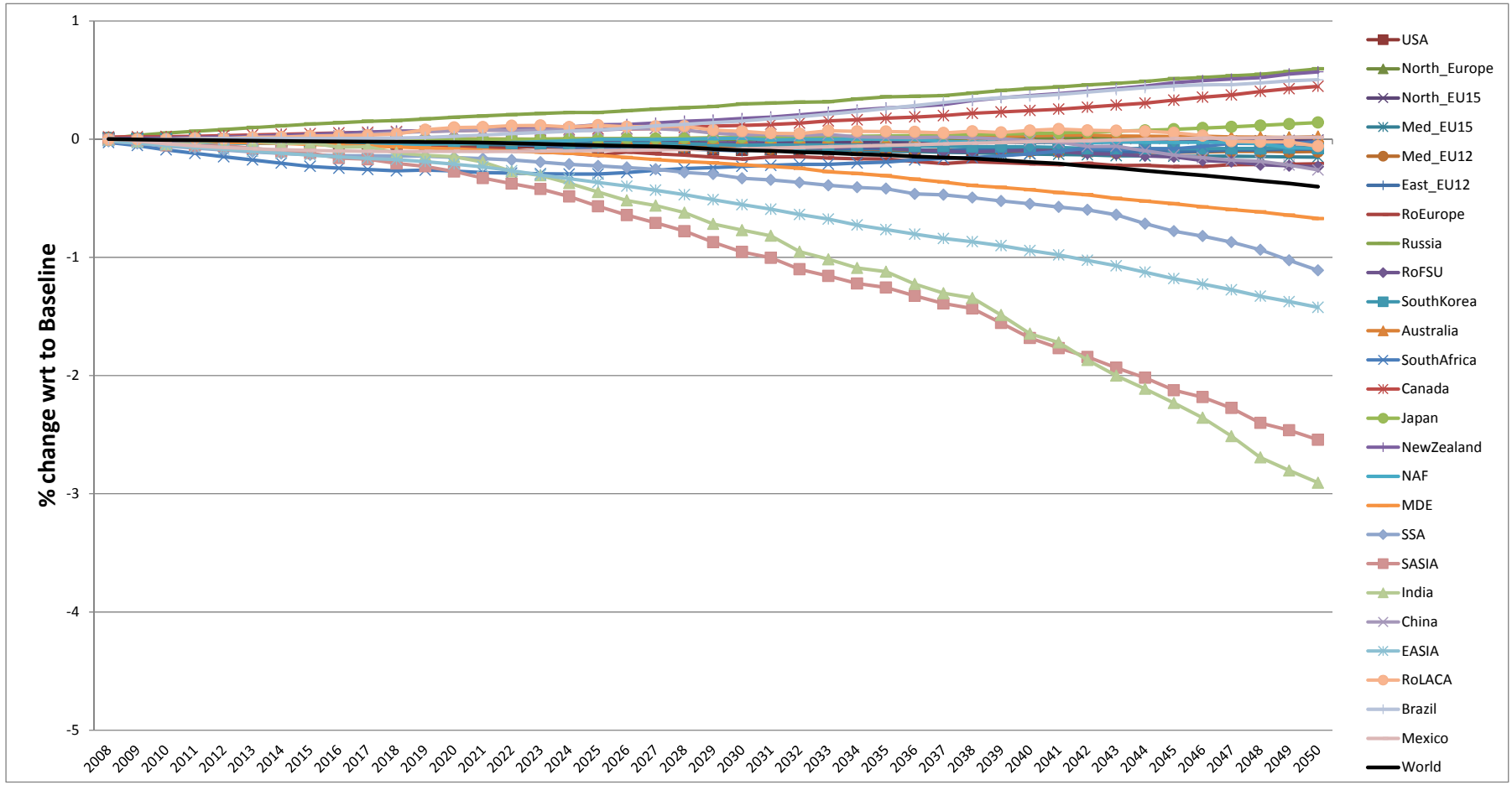
Thanks!

This research project has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under the grant agreement n° 266992 (Global IQ)

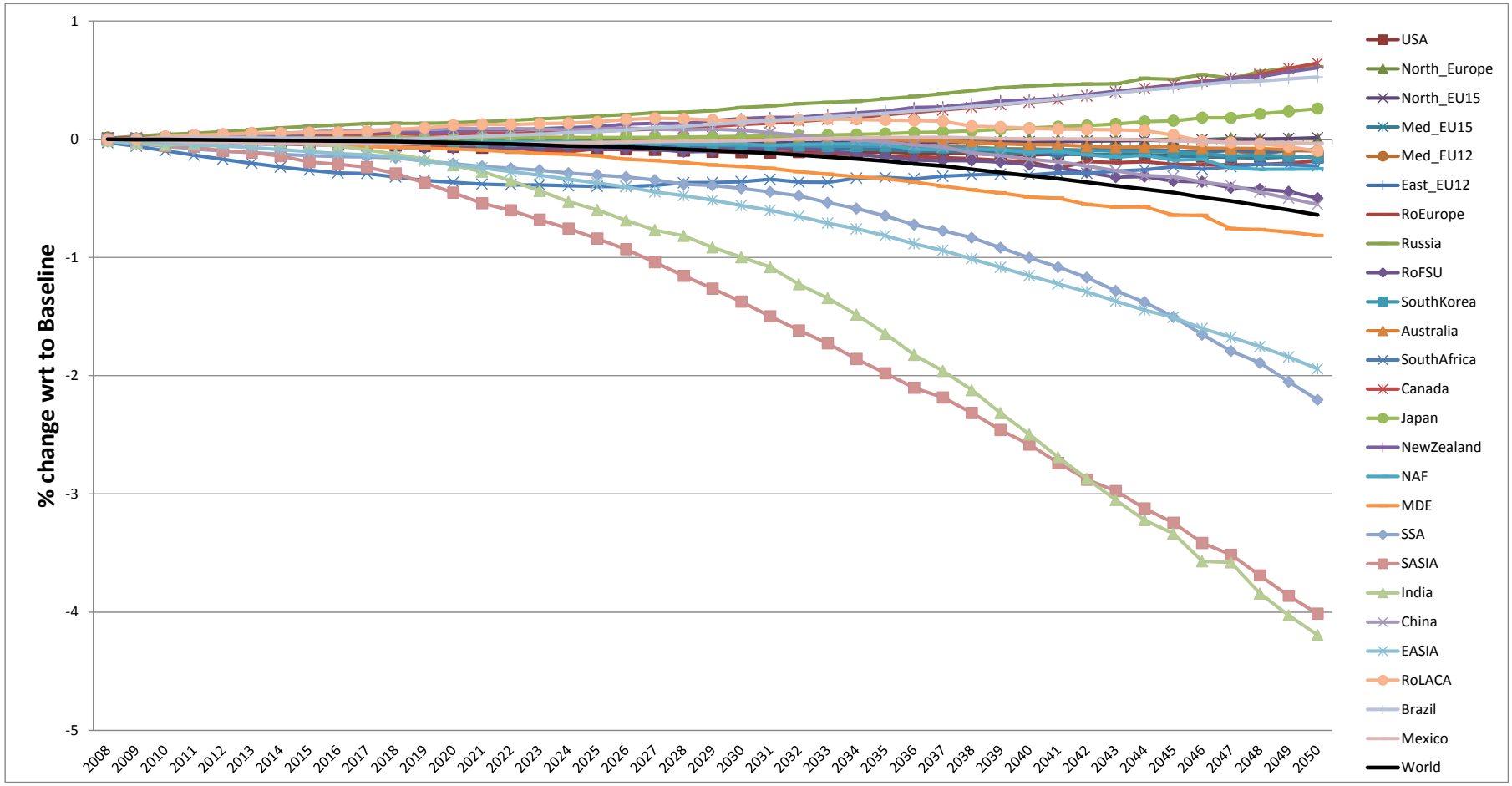
RCP2.6: climate-change impact on macro-regional GDP



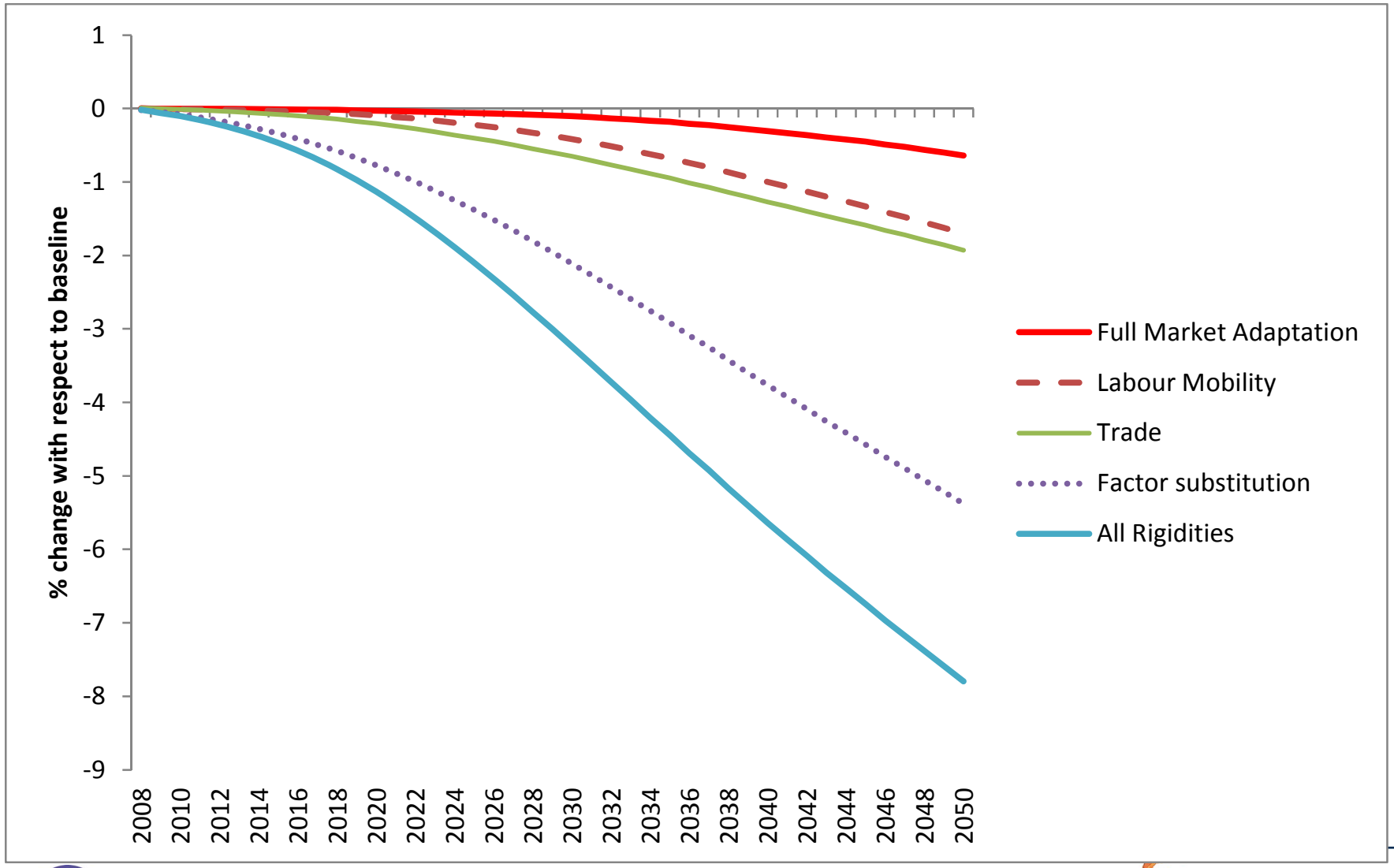
RCP6.0: climate-change impact on macro-regional GDP



RCP8.5: climate-change impact on macro-regional GDP



Climate change impacts on GWP for RCP 8.5 vs a Full adaptation baseline



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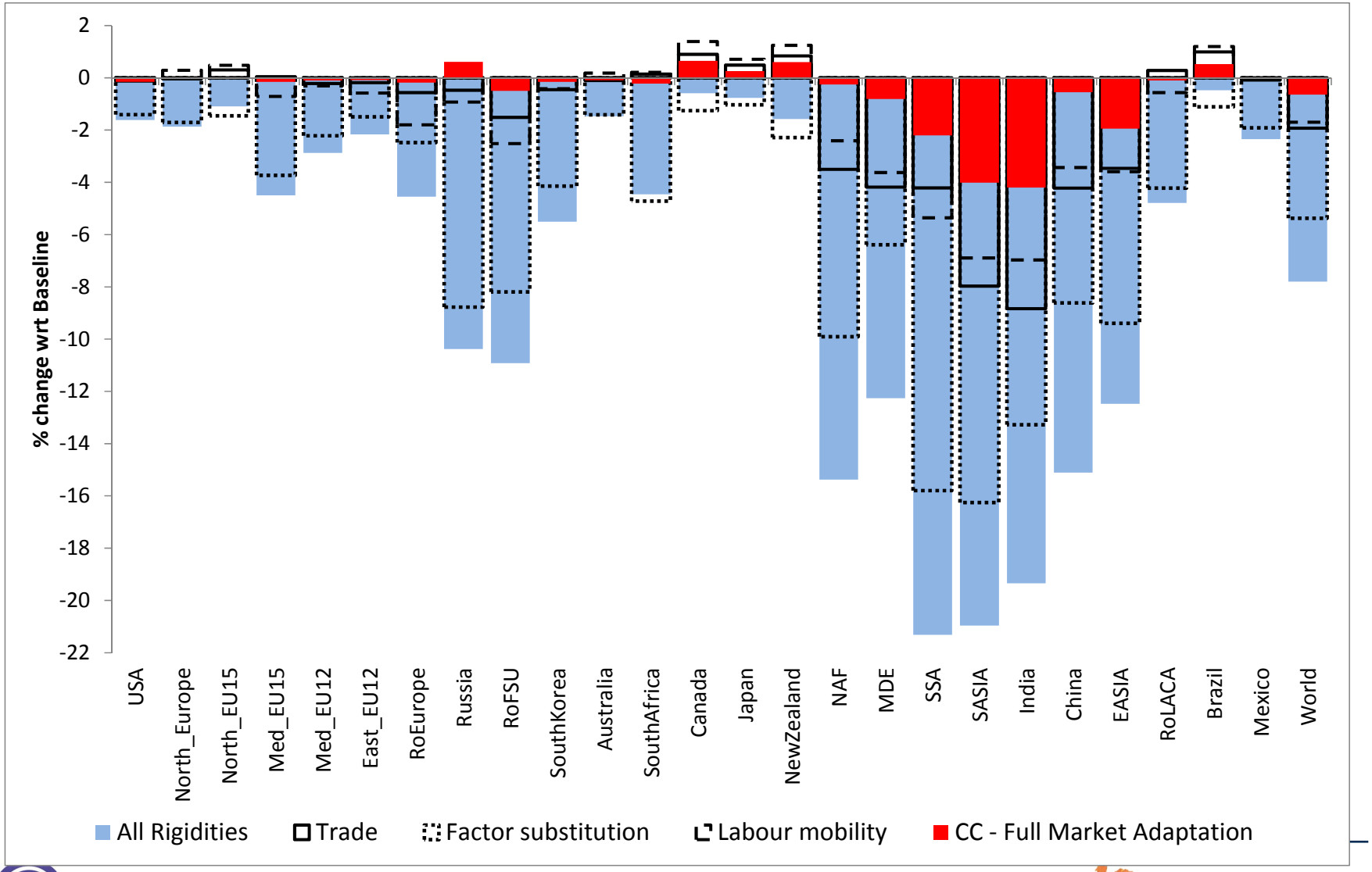
RCP 8.5 impacts on regional GDP with Limited adaptation vs a Full adaptation baseline



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