Economic assessment of climate change impacts and the role of autonomous adaptation mechanisms

Francesco Bosello

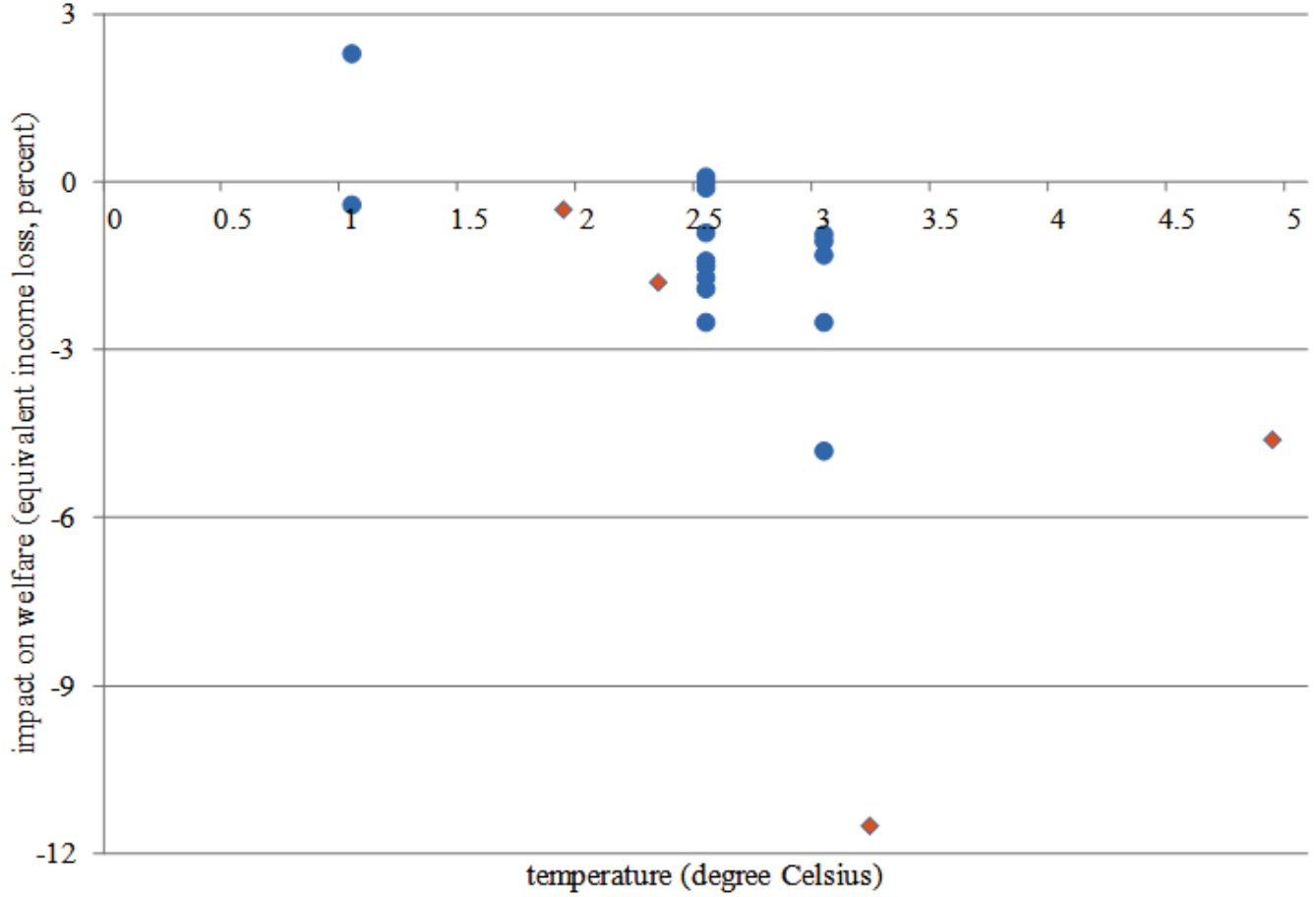
CMCC, FEEM, University of Milan, Department of Environmental Science and Policy

Ramiro Parrado – CMCC, FEEM

ISPRA, October 6th, 2017

The issue in a nutshell

«Point estimates» of climate change impacts on world GDP



Source: IPCC AR5 (2014)

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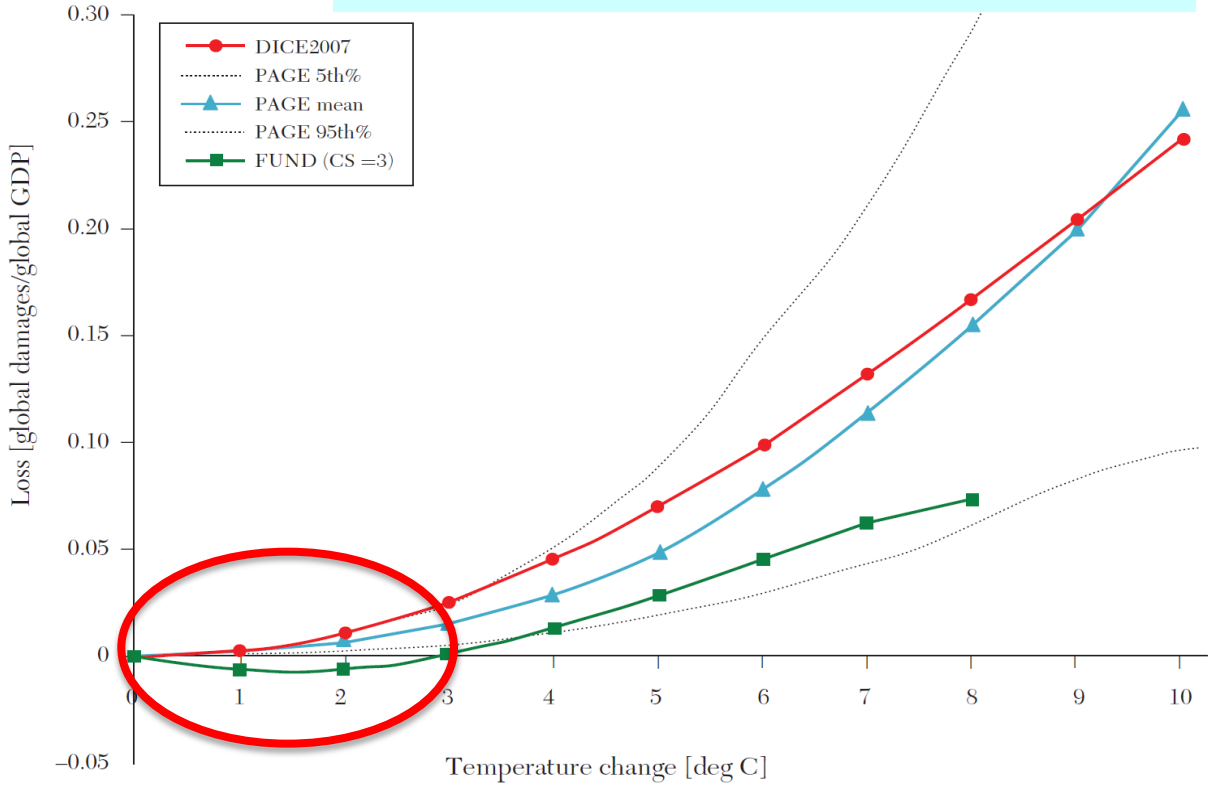
The issue in a nutshell

Examples of reduced-form climate change damage functions (CCDF)

$$"GDP" \ loss_{i,t} = f(T_{i,t})$$



Source: IPCC AR5 (2014)

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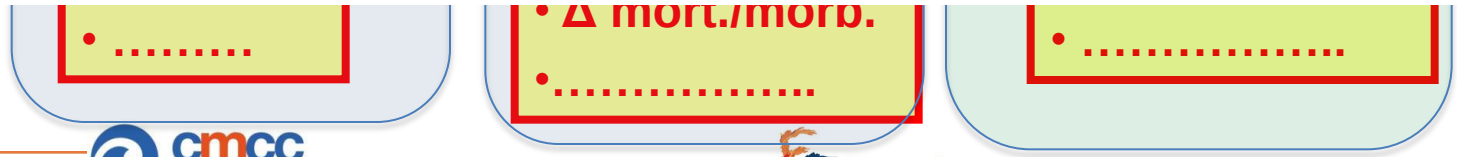
The issue in a nutshell

An alternative approach

This methodology has been extensively used since the beginning of 2000, see e.g.: Deke et al. (2001); Darwin and Tol (2001); Bigano et al (2008); Aaheim et al., (2010); Bosello et al. (2006, 2007, 2014); Eboli et al, (2010); Roson and Van der Mensbruegghe (2010); Ciscar et al, (2011, 2013), ADB (2015) OECD (2016).

Main strenght: ability to capture the role of market adjustments or of market driven adaptation triggered by climate «shocks» due to the multi-sector/multi-country nature of CGE models, their explicit representation of domestic-international market exchanges, and endogenous price formation.



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The issue in a nutshell

But economic assesments of climate change impacts conducted with CGE models tend to «produce» low damage estimates

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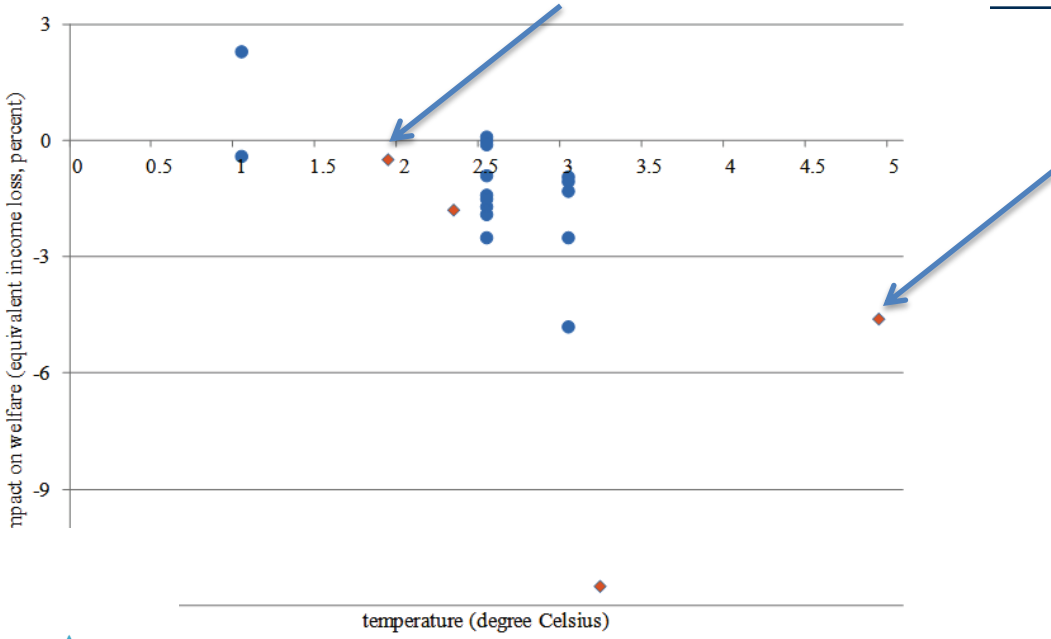

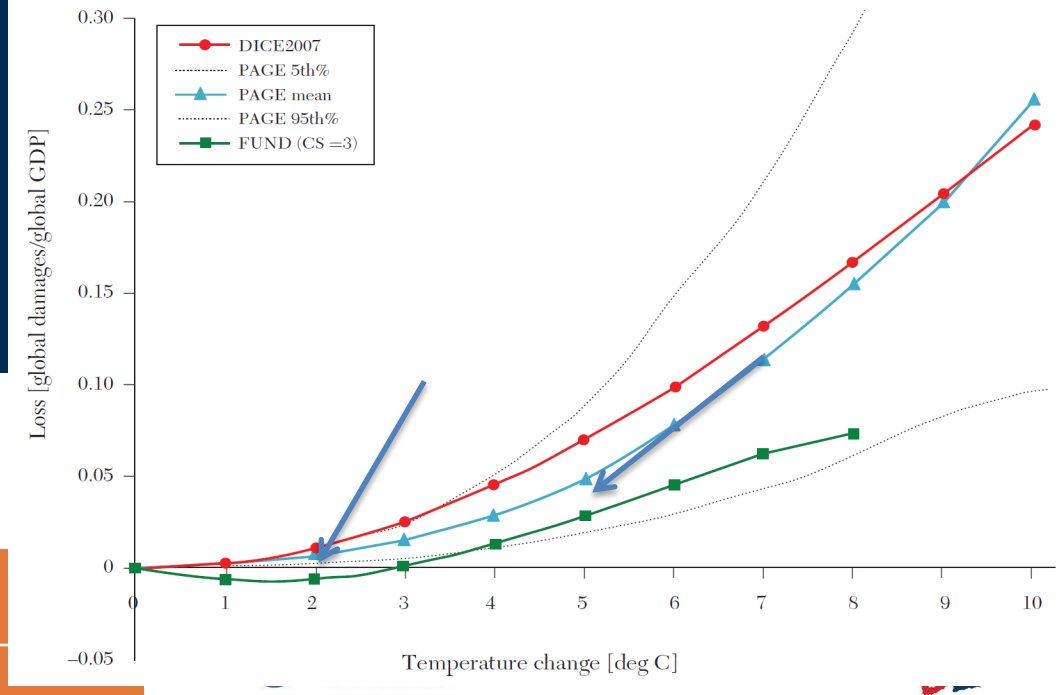

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The issue in a nutshell

Many reasons for that (Patt et al 2011, Pindick, 2013, Stern 2013):

- ✓ Unability to capture «non market» losses referred to non marketable items (e.g. ecosystem services, changes in mortality/morbidity), institutional «failures» (lack of adaptive capacity), social conflicts…
- ✓ The main loss indicator is GDP a «flow» and not a «stock» measure.
- ✓ Instantaneous and frictionless recovery after a shock → too optimistic in assuming substitutability across/mobility of factor of productions.

Objectives

✓Try to assess the economic relevance of climate change using a recursive-dynamic CGE model → incorporating latest evidence on different impacts categories

✓Quantify the role of "market driven adaptation" in determining the final impact. Firstly "full market-driven adaptation" is assumed, then limits or frictions in market adjustments is introduced.

✓ Construct reduced-form climate change damage functions starting from the CGE results and compare with those used by well established "hard linked IA models".

The model: ICES

Recursive dynamic computable general equilibrium (CGE) model

- ✓ Based on the GTAP 8 database (Narayanan et al. 2012). Calibration year 2007
- ✓ Simulation period: 2007-2050 in one-year time steps
- ✓ 25 countries/regions (this study)
- ✓ 19 sectors (this study)
- ✓ (as standard in CGE) Inter sectoral and international trade flows explicitly modelled → optimizing agents' endogenous response to (endogenous) price signals represents «market-driven adaptation»

Summary of scenarios

- Economic reference: SSP2 ("middle of the road") (O'Neill et al. 2012)
- Climate change impacts reconstructed for RCPs: 2.6, 6.0 and 8.5 (Van Vuuren et al. 2011)

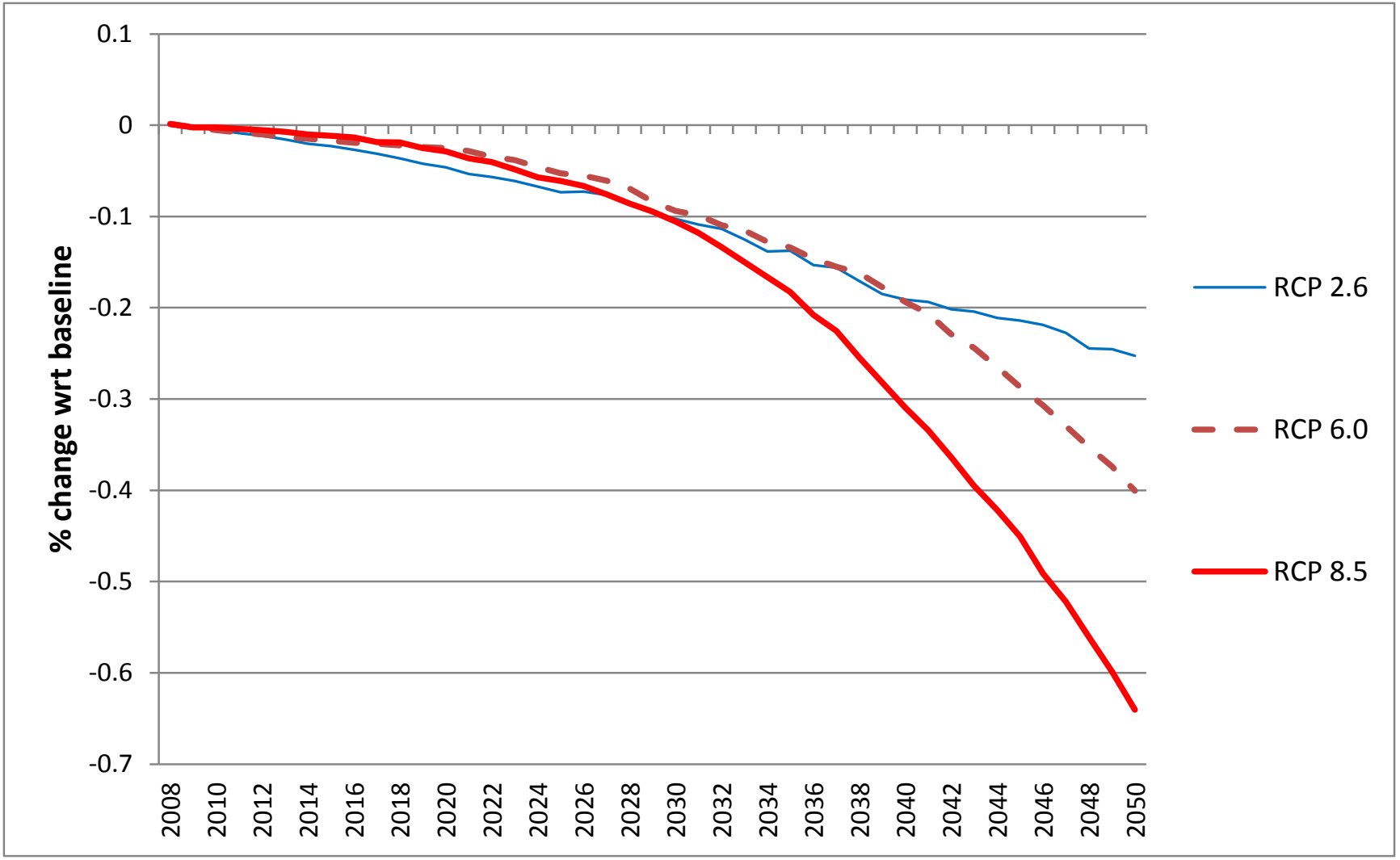
+ "Full" adaptation ("default" adjustment mechs.)

- As above, but with "Limited" adaptation:
  - 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).

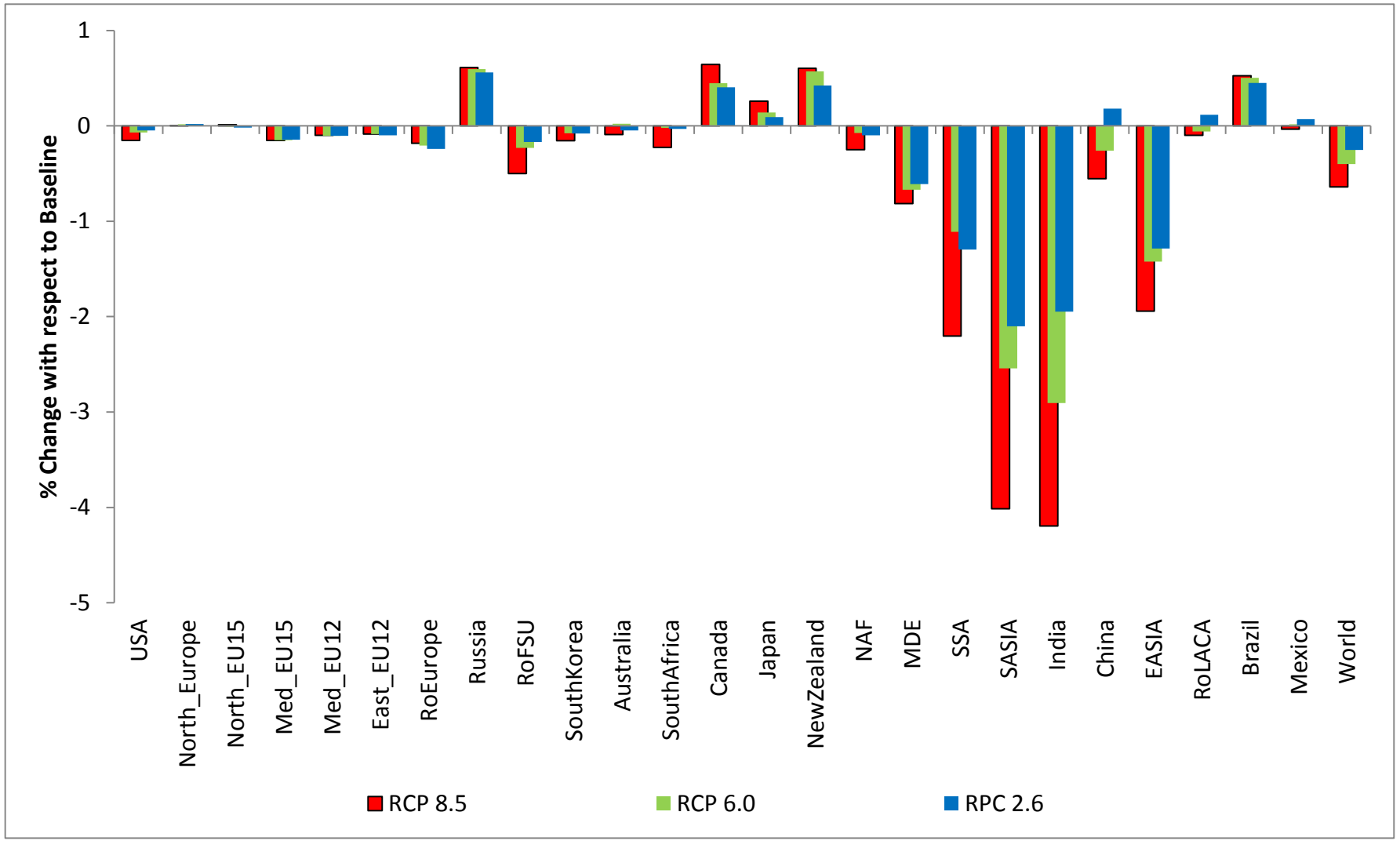
Climate change impacts: Sources

CC Impacts	Sources	Available Scenarios
Agriculture	PIK - LPJmL ISIP-MIP runs	RCPs 2.6, 6.0, and 8.5
Health	Tol (2002)	1° C
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) CLIMATECOST project	A1B
Fisheries	Cheung et. al (2010) SESAME project	A1B
Ecosystem	Warren et al (2006)	1° C

Climate Change Impact on Gross World Product



CC impacts on GDP in 2050 – regional breakdown



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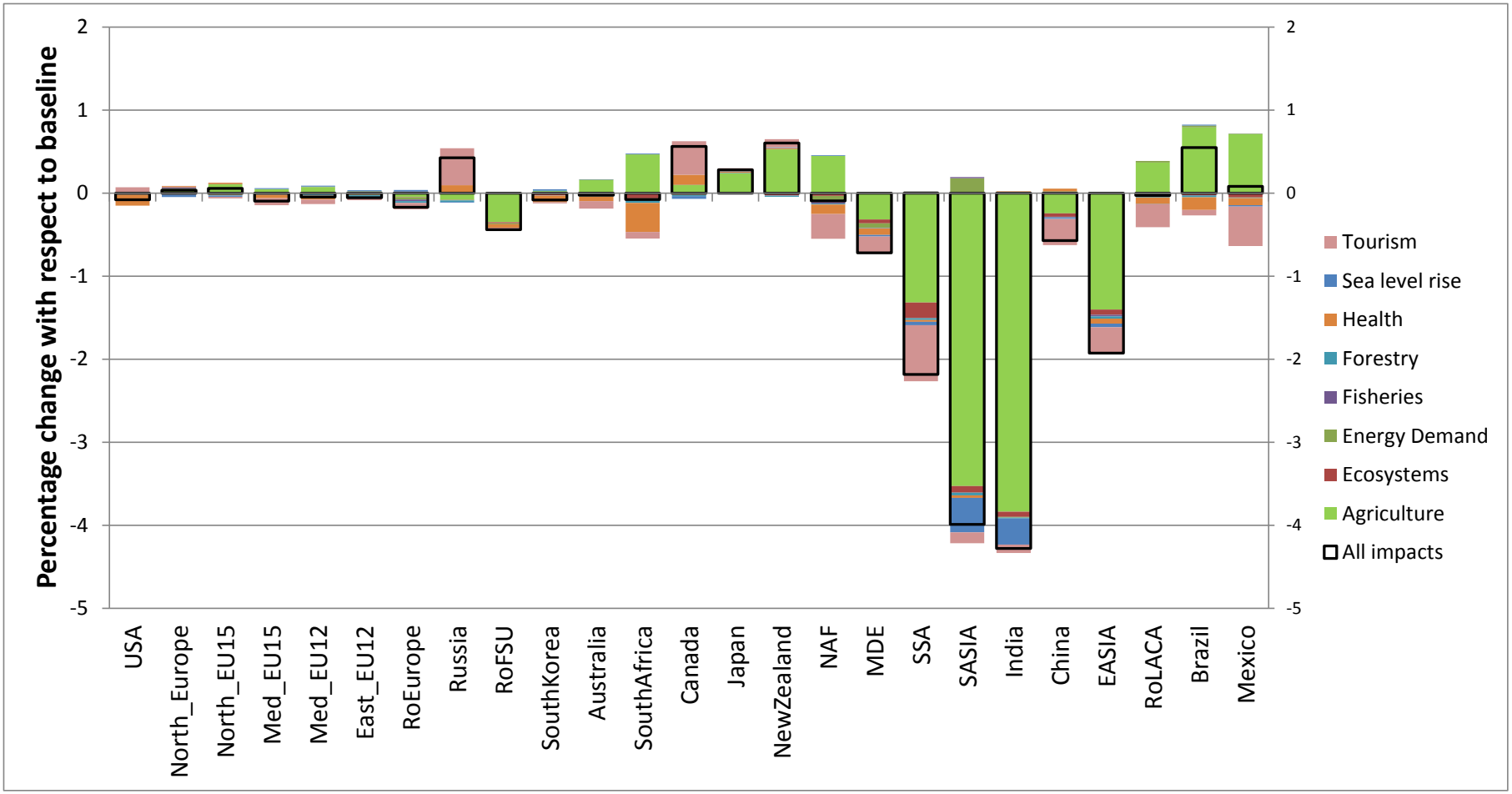
CC impacts on GDP in 2050 – decomposition RCP 8.5



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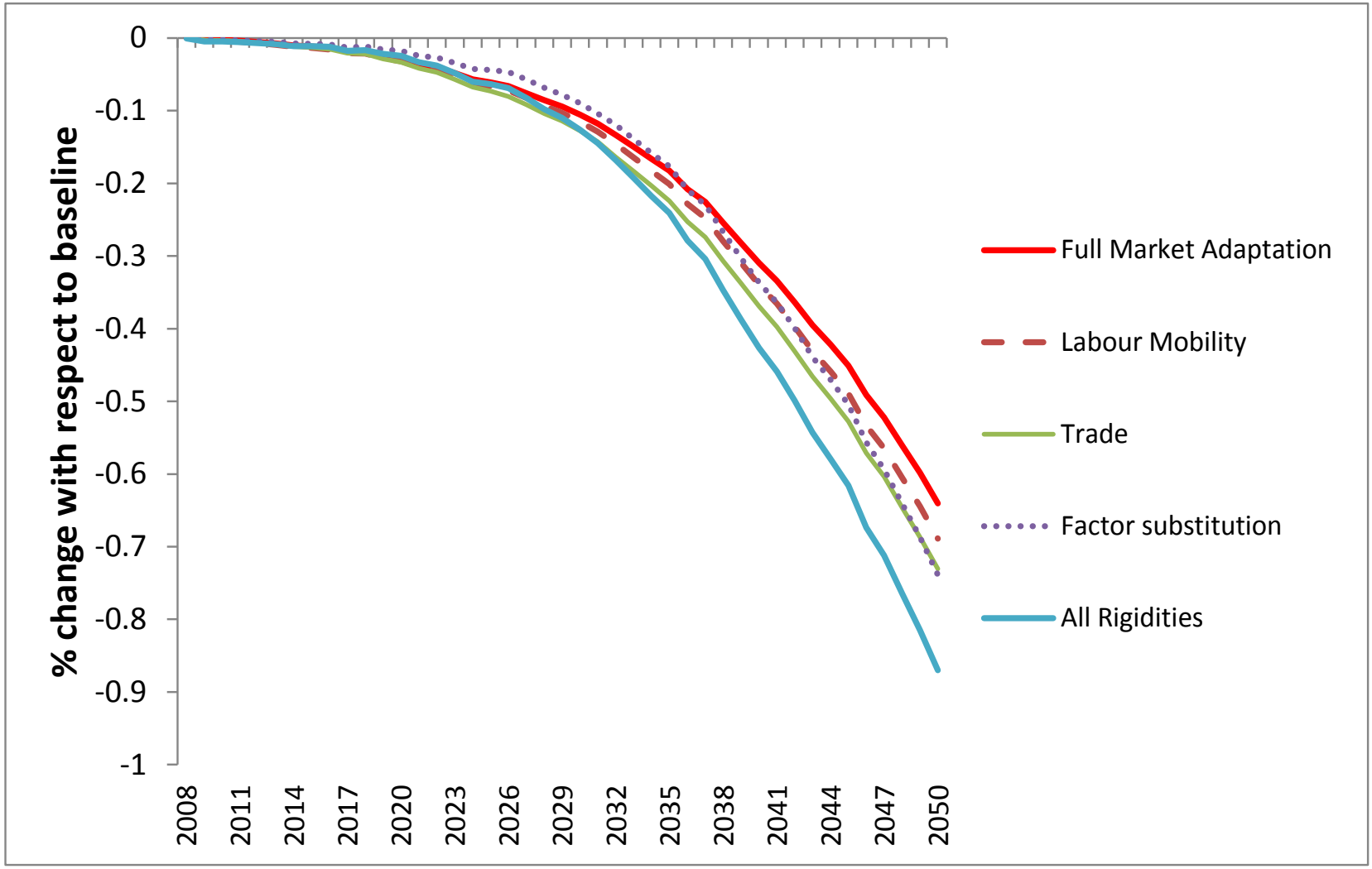
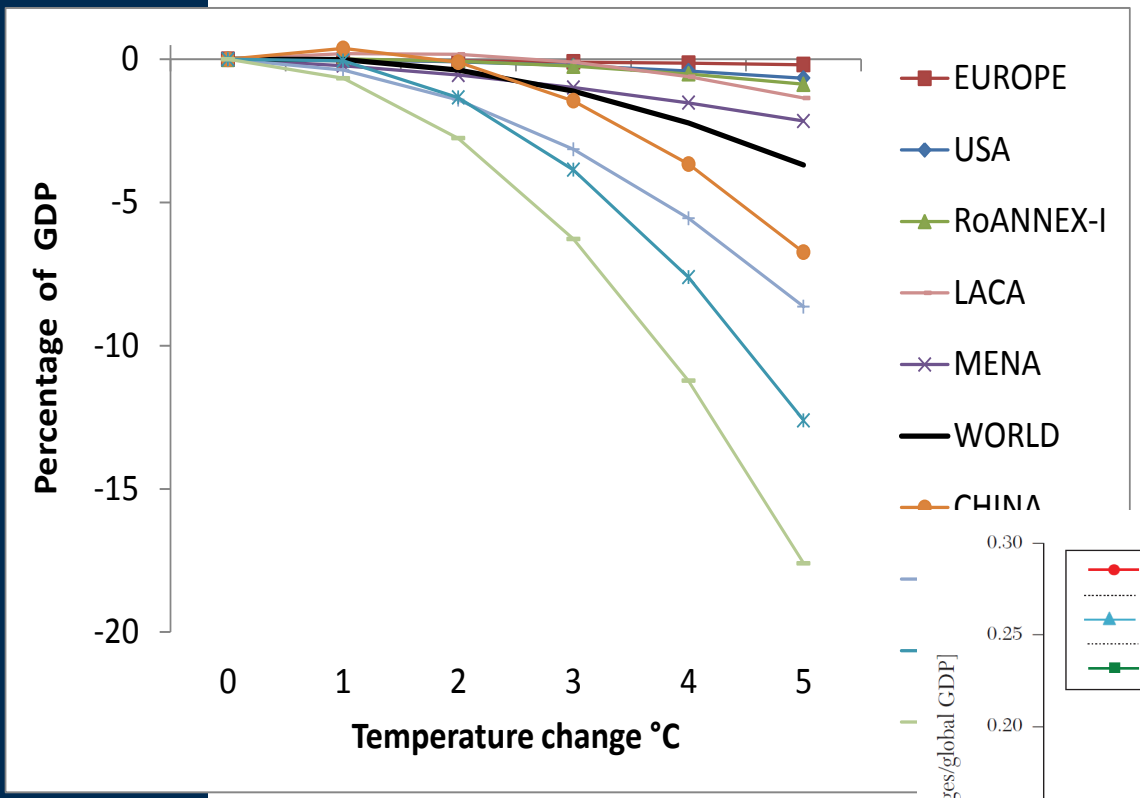
“Limiting” adaptation: CC impacts on GWP (RCP 8.5)

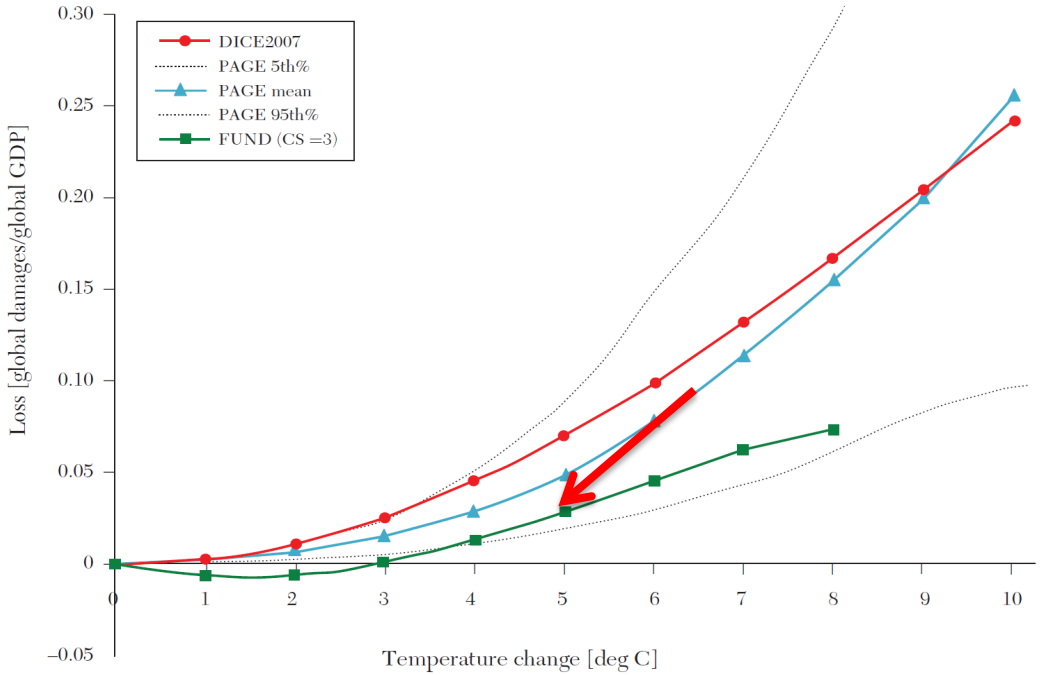


Reduced-form climate change damage functions (CCDF)

- ✓Using the different RCPs to obtain different (namely 3) temperature increases and impacts and GDP effects in the same year for each region, we then interpolate the function (To “clean” or control for the social economic factors we selected as reference one single year (2050))
- ✓We did this first accounting for just ***smooth market impacts***.
- ✓Then including a ***catastrophic damage*** component following Nordhaus and Boyer (2000) and Nordhaus (2007).
- ✓Finally adding limits to adaptation

Reduced-form CCDF, «smooth impacts»





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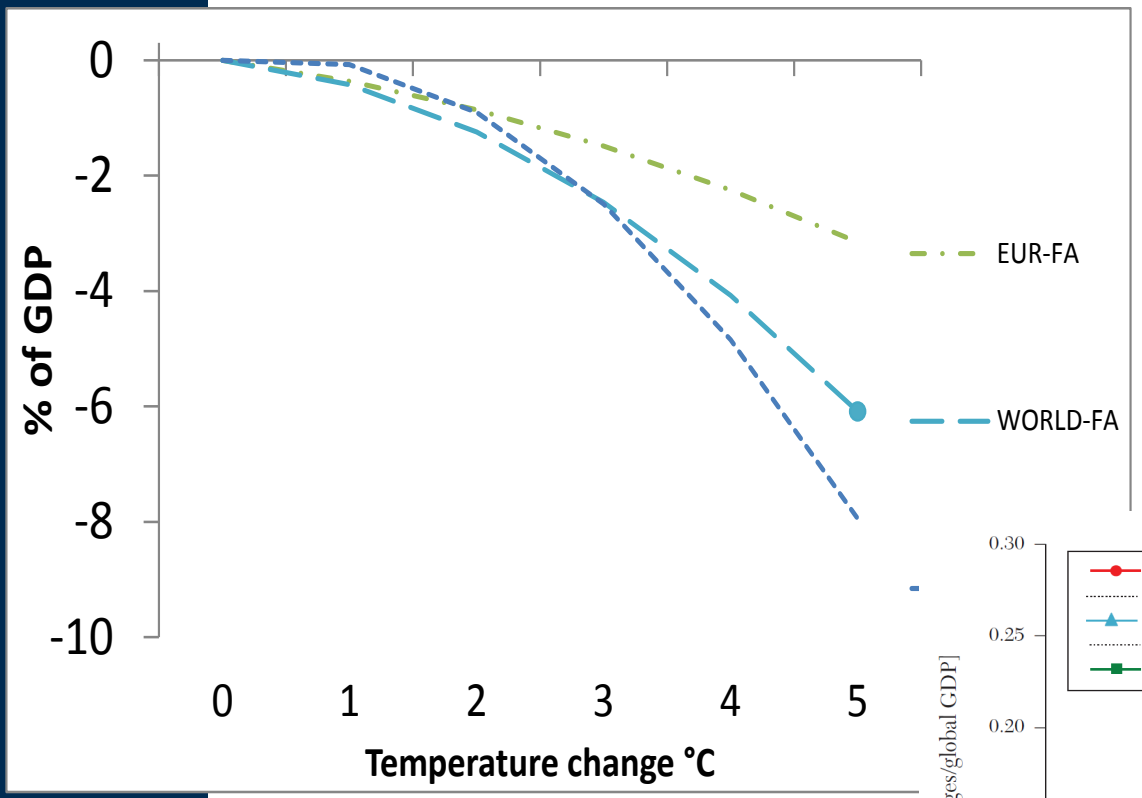
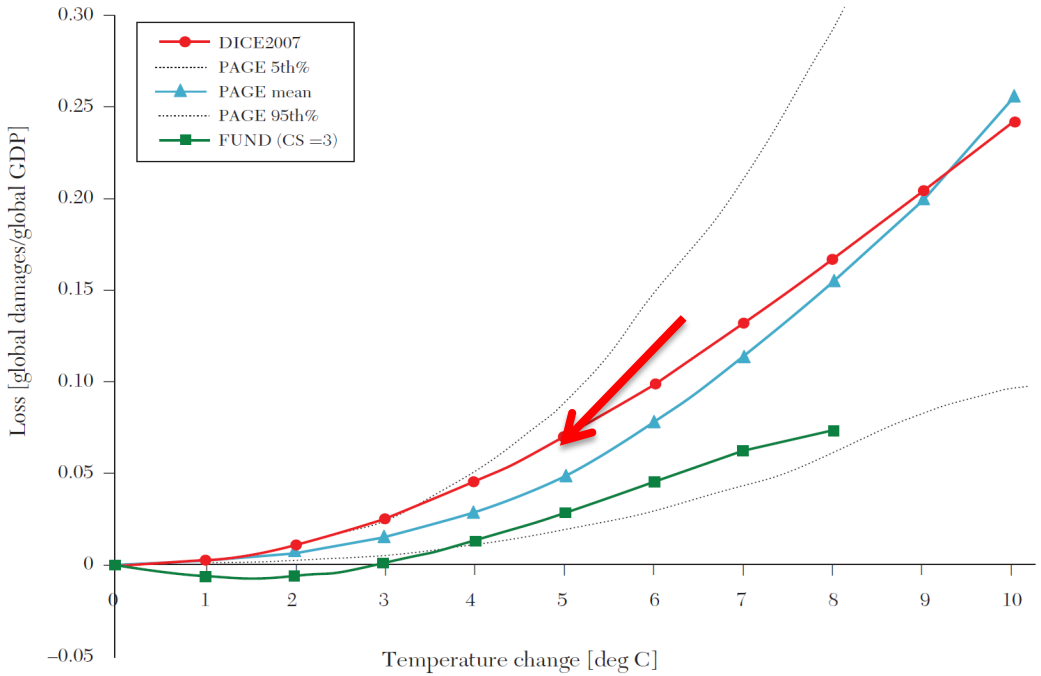
Reduced-form CCDF, «smooth + catastrophic impacts»





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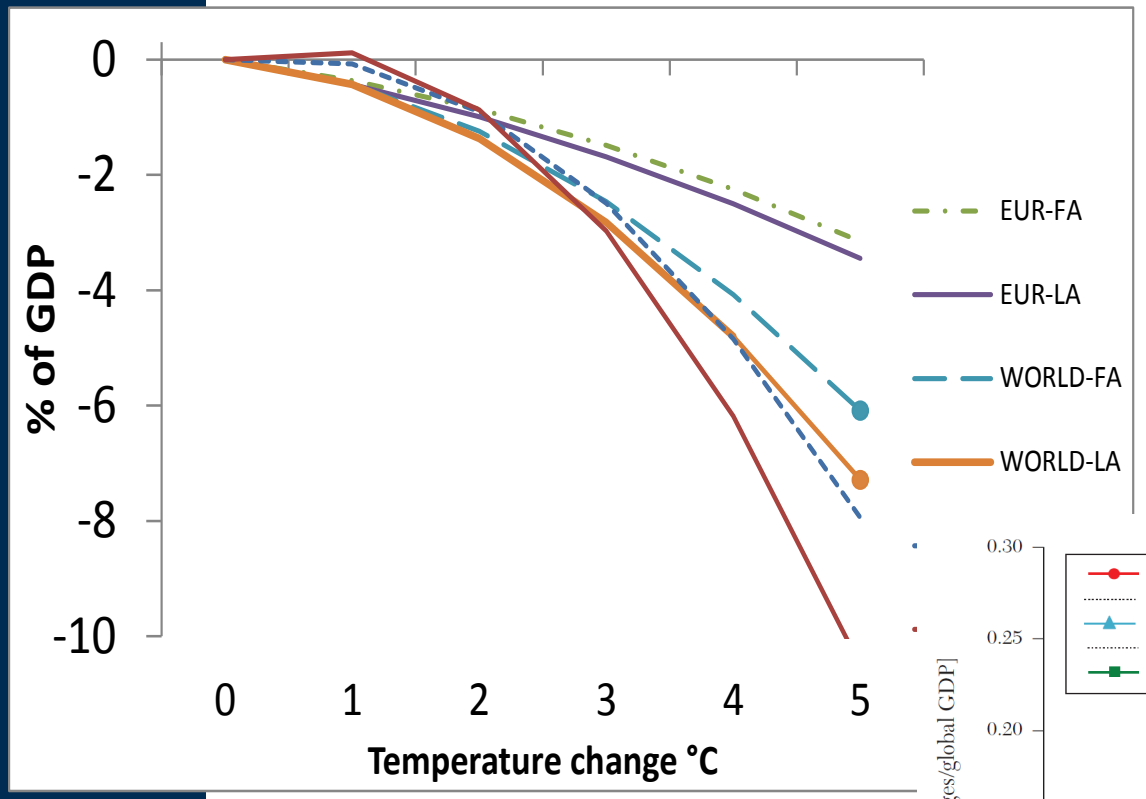
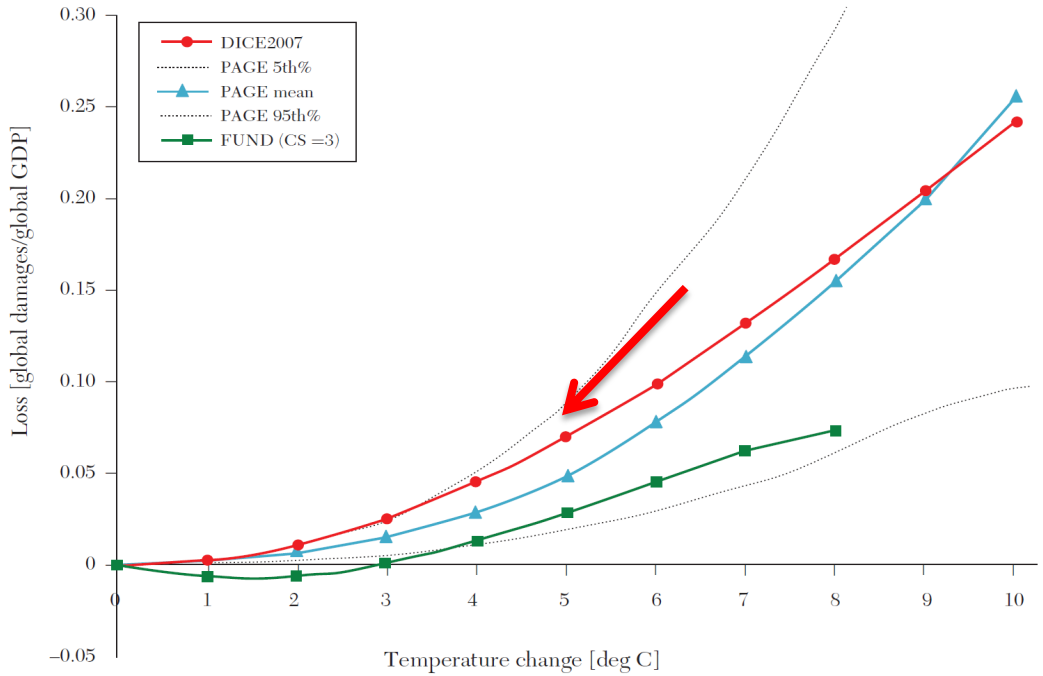
Reduced-form CCDF, «smooth + catastrophic impacts + lim. ad.»





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Conclusions (1)

✓In 2050 total costs roughly amount to 0.64% of GWP in RCP 8.5 (2.5° C increase).

✓Aggregate figures hide important regional asymmetries: 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 roughly 2% of their GDP in 2050 in RCP 8.5).

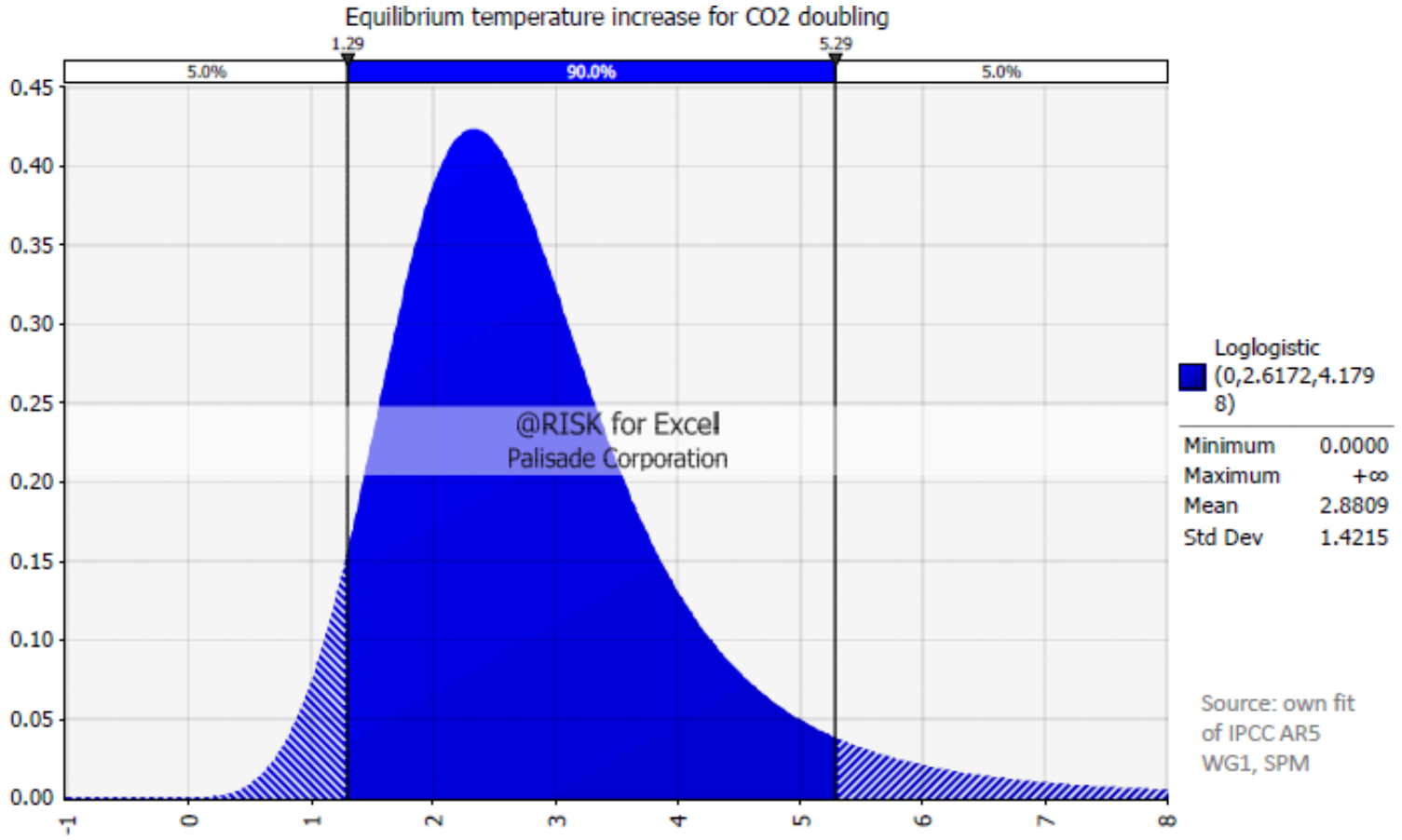
✓Introducing rigidities in market adjustments increases climate change costs (by roughly 30%), but does not change substantively the picture. Key is the modelling of catastrophic outcomes

✓In the shorter term, trade is a more important source of impact smoothing, in the longer term it is the lower degree of substitutability across primary factors.

Conclusions (2)

- ✓ When the comparison is “even” CGE models do not provide lower estimates of climate change damages compared to “hard linked” IA models
- ✓More research is needed, at least:
  - ✓Investigate the role of the social economic context (the structure of the economy) in impact determination
  - ✓Better define the range of uncertainties on key parameters
  - ✓ More observations to calibrate the reduced-form damage functions (very limited knowledge “beyond 3° C”)

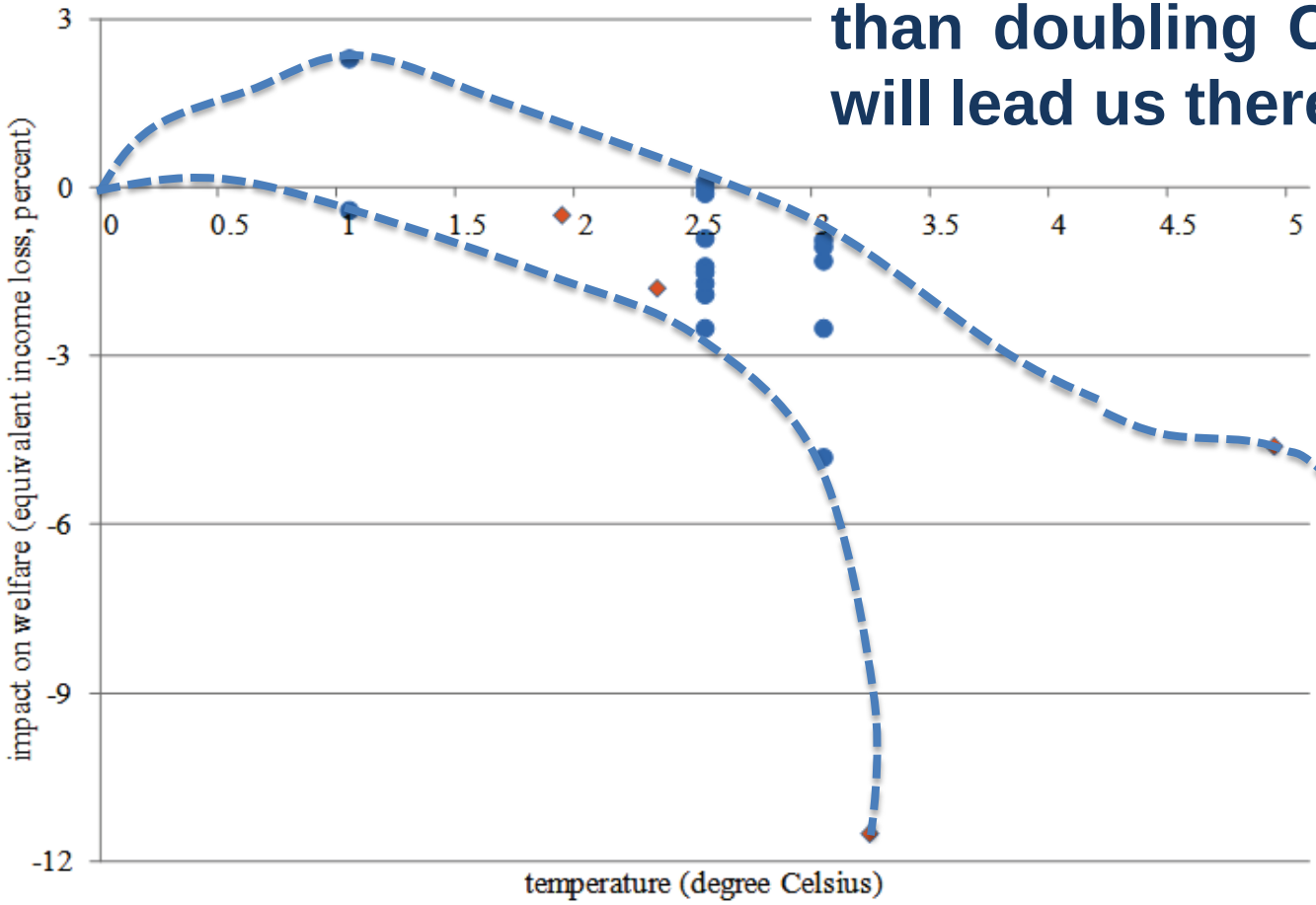
The need for a precutionary approach



With a doubling of CO2 concentration there is the 5% probability of experiencing increases of temperature > 5 ° C

The need for a precautionary approach

Both RCP 8.5 and 6 (more than doubling CO2 conc.) will lead us there



10-30% global GDP loss

(Weitzman, 2014)

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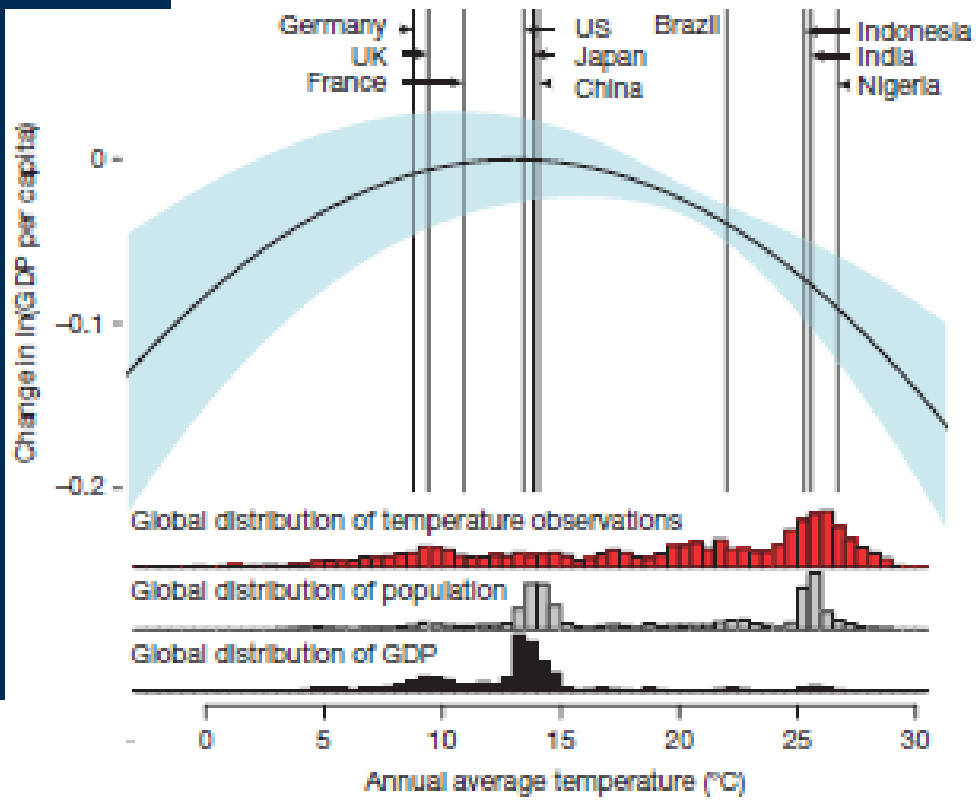
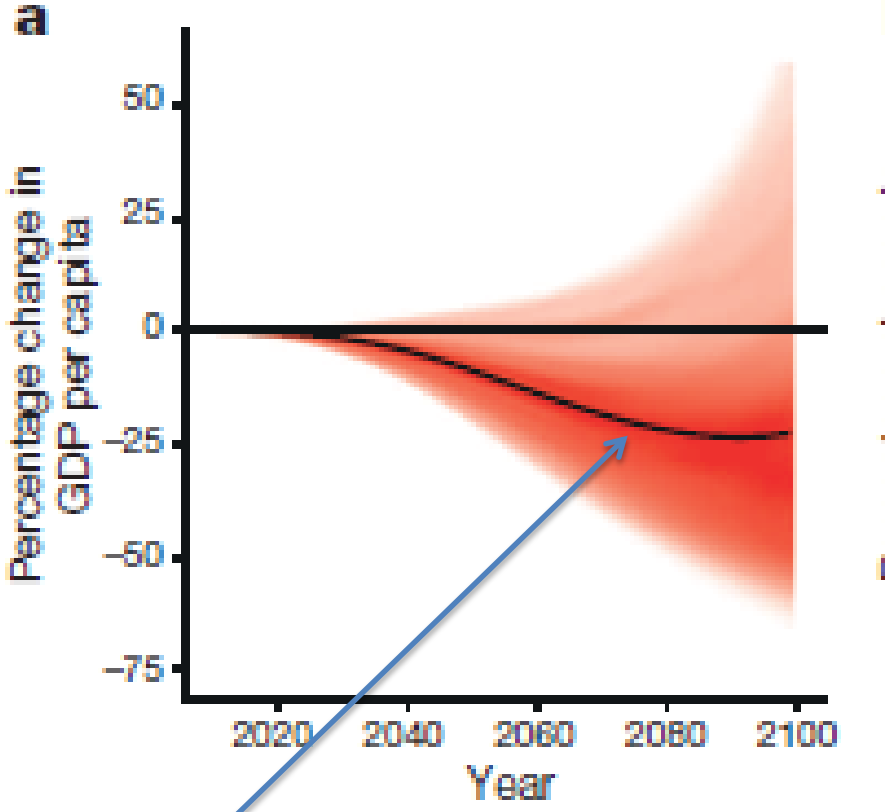
Support from econometrics





Source: Burke et al (2015)

23% median global GDP loss in RCP 8.5

Thanks!

This research is based on the outcome of the European Union's Seventh Framework Programme (FP7/2007-2013) under the grant agreement n° 266992 (Global IQ)

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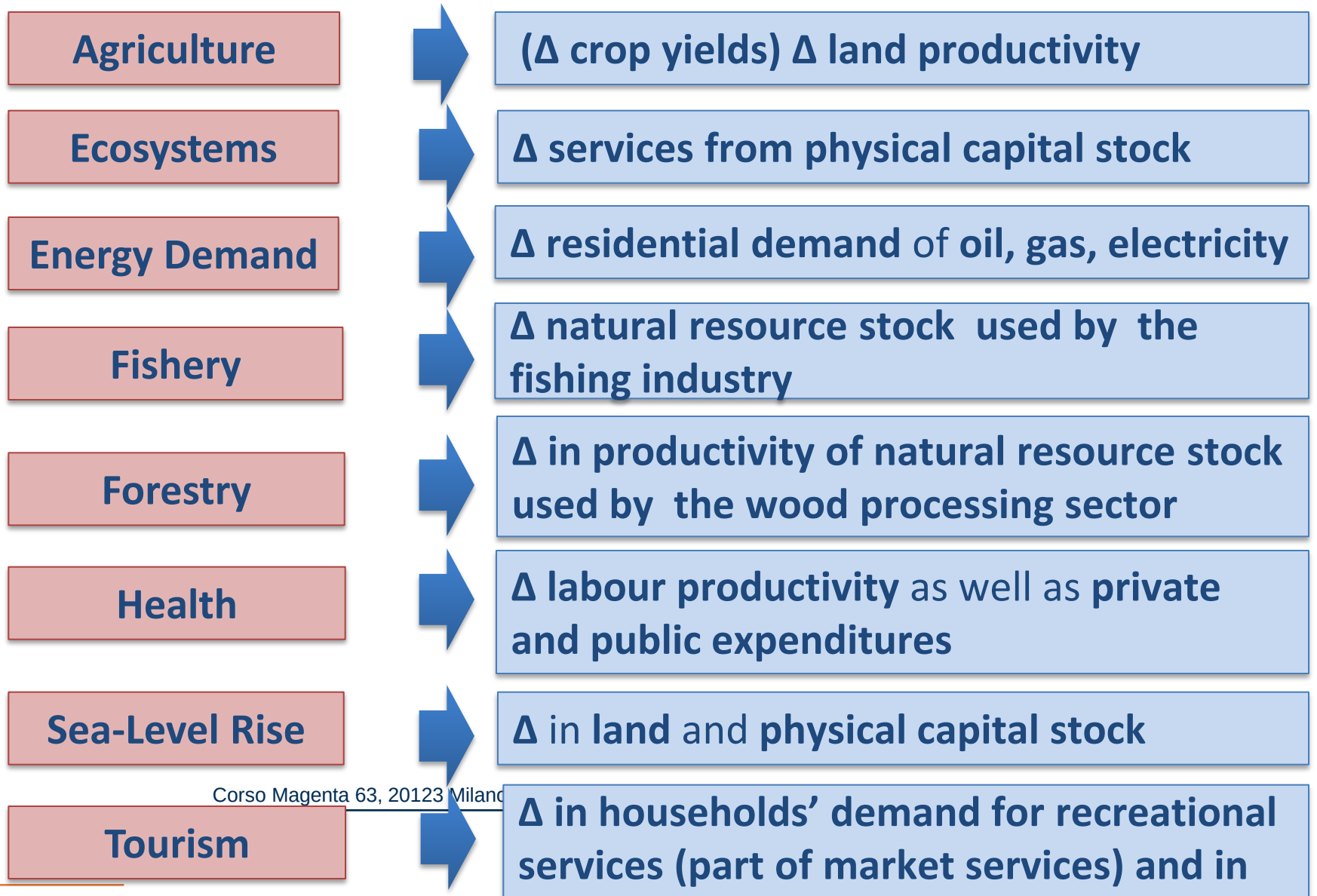
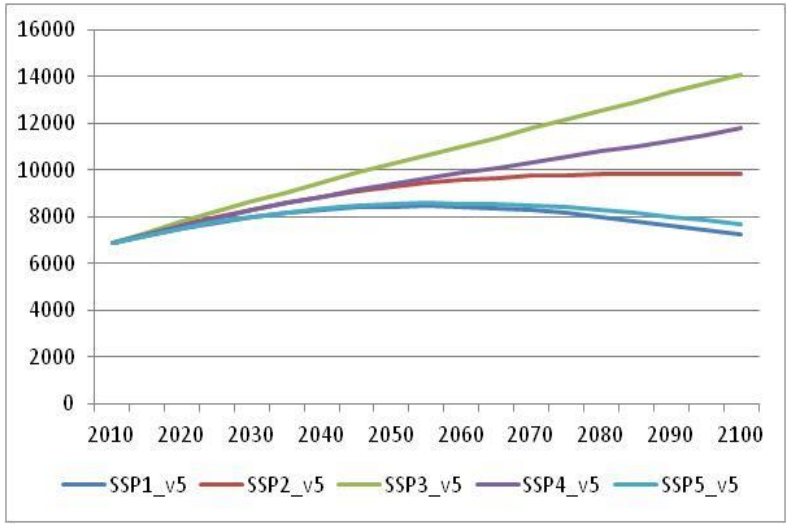
Climate change impacts assessed and modelling strategy

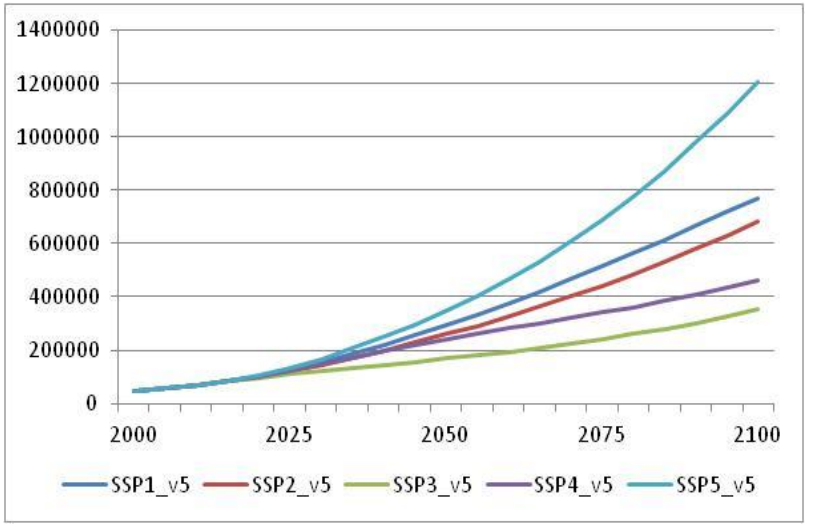


Macro economic drivers of SSP2

World population SSPs (Million)

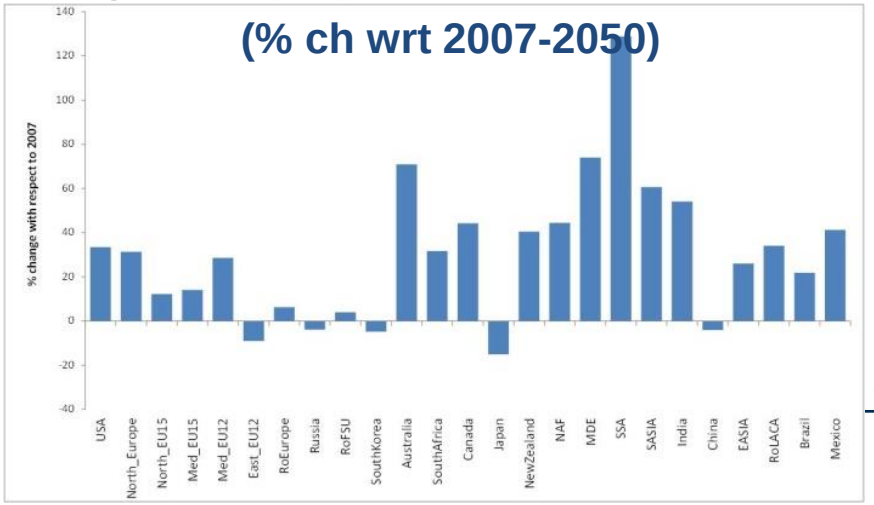


World GDP SSPs ($ Billion)



Regional population trends SSP2

(% ch wrt 2007-2050)



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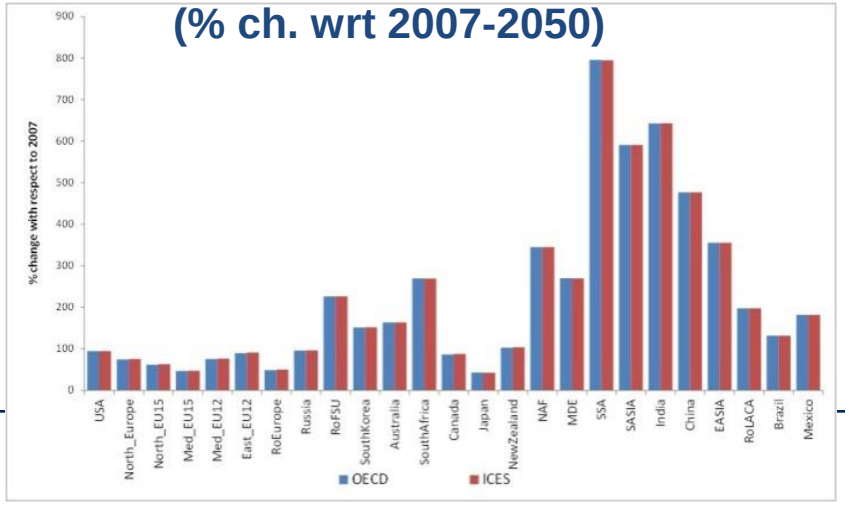
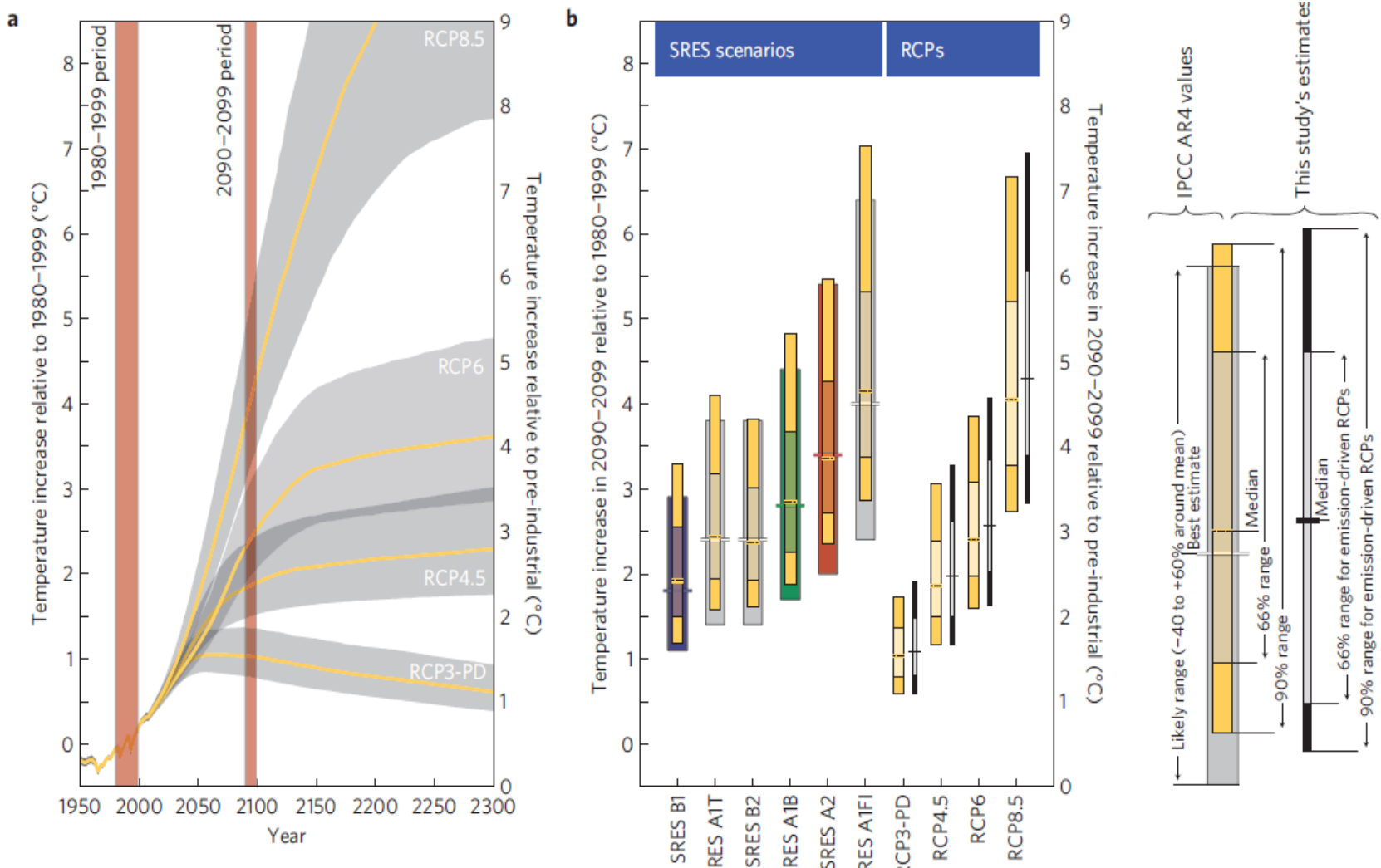
Regional GDP trends SSP2

(% ch. wrt 2007-2050)



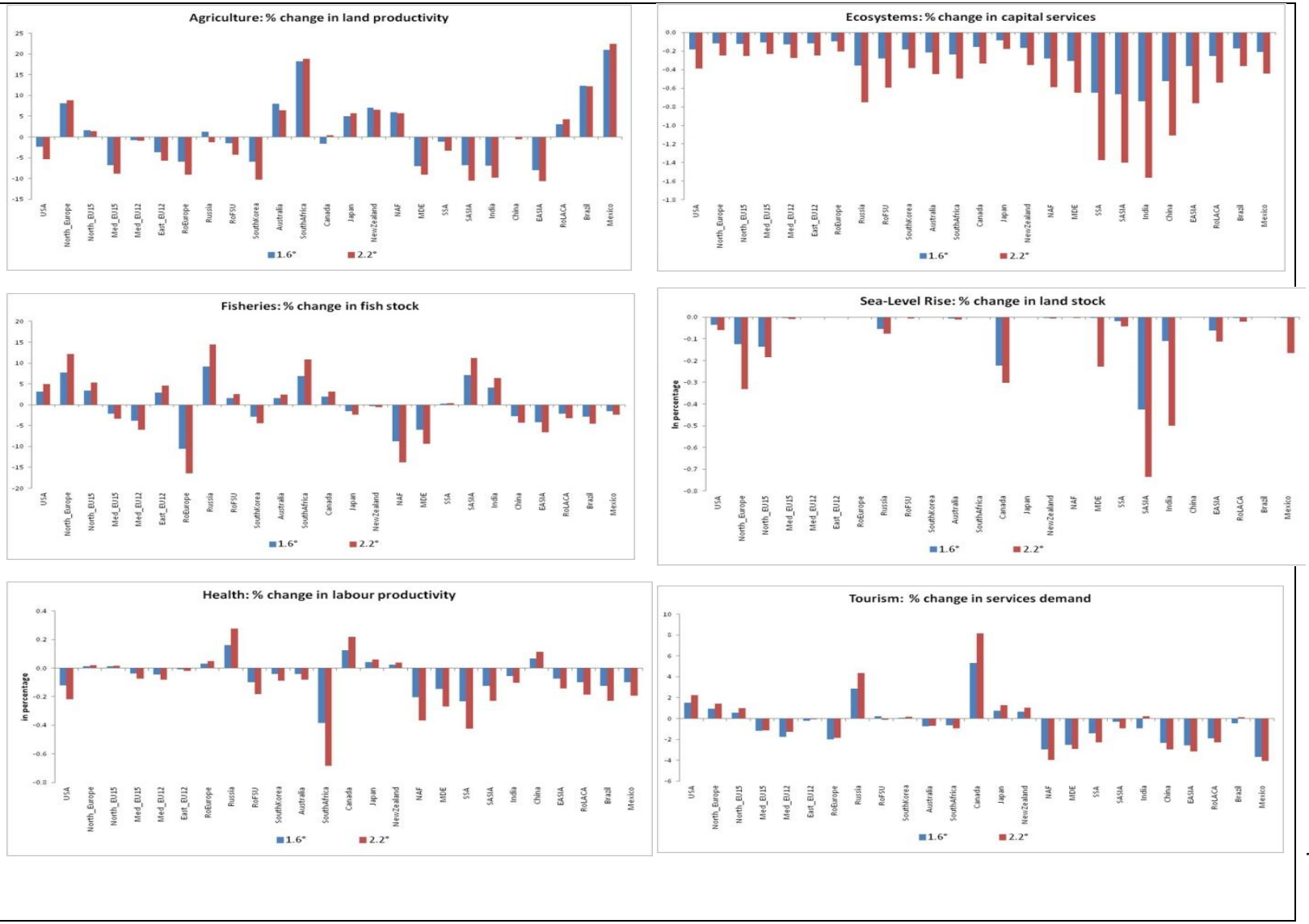
Source: https://secure.iiasa.ac.at/web-apps/ene/SspDb/dsd?Action=htmlpage&page=welcome

Temperature increase in the different RCPs



Source: Rogelj et al (2012)

Climate Change Direct Impacts (selected)

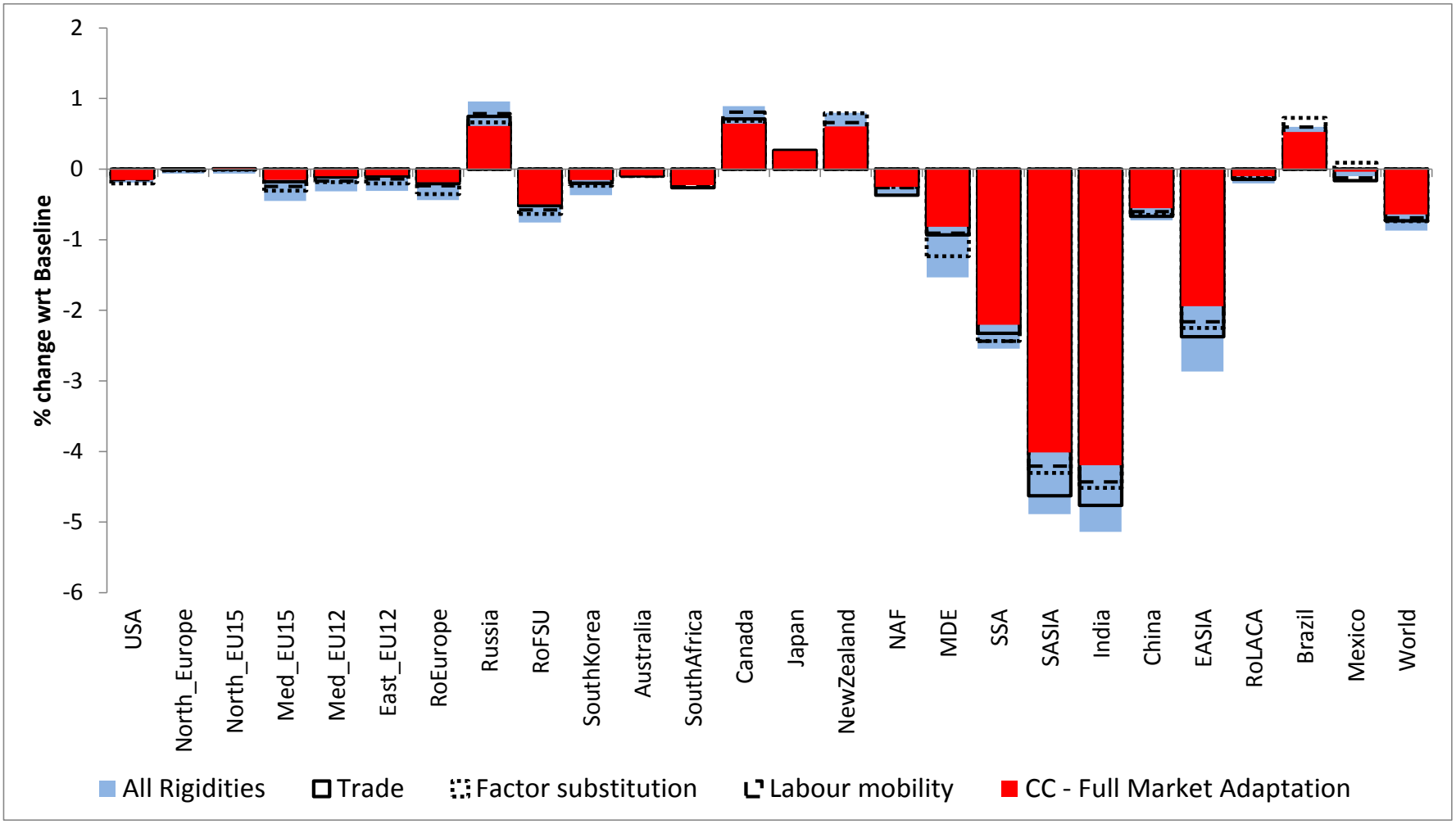


«Limiting Adaptation»

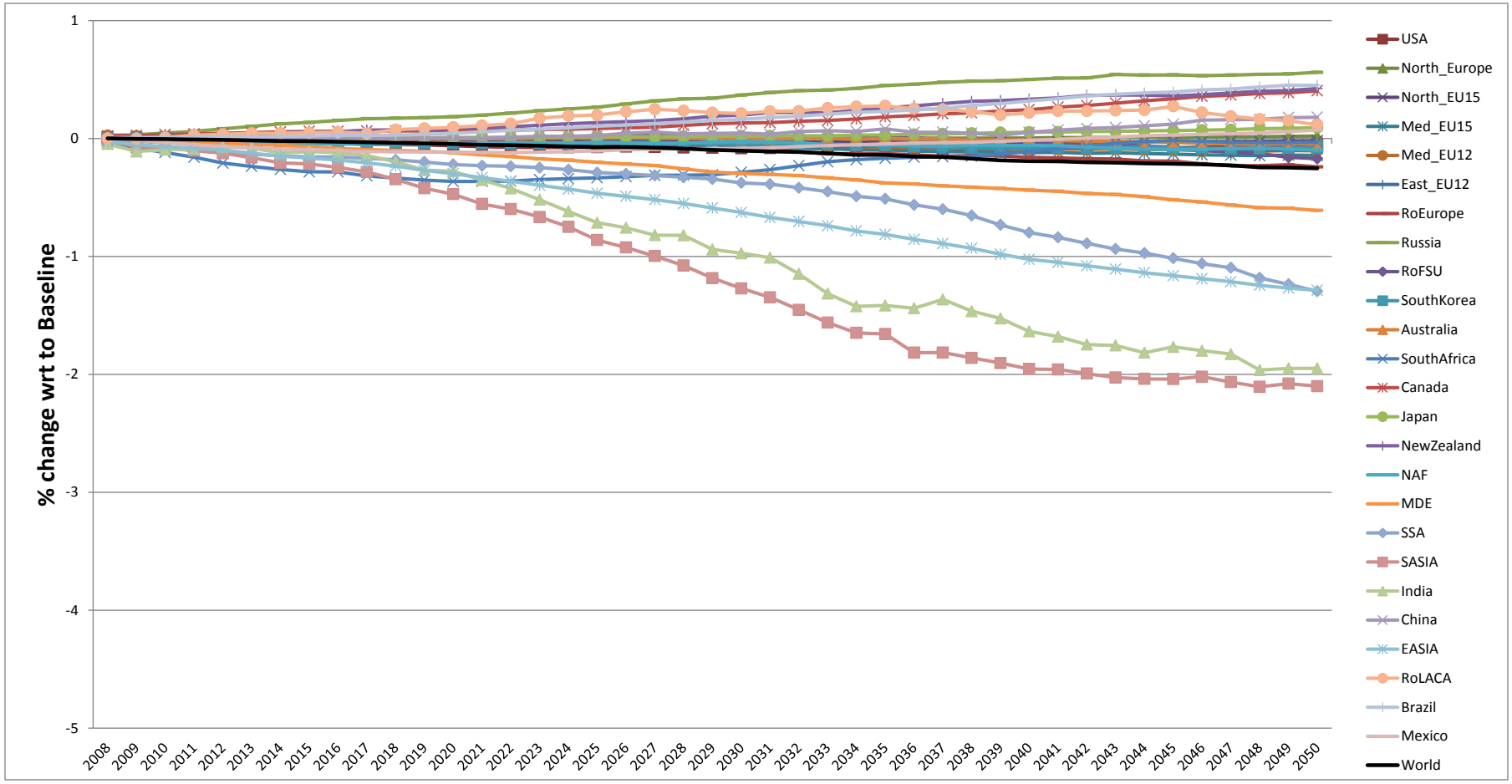
- "Trade more difficult" (Armington elasticities reduced to 75%): *LA-TR*
- "Primary factor substitution more difficult" (substitution elasticity reduced to 75%): *LA-PFS*
- "Moving labour more difficult" -- Limited labor mobility allowing for wage differences: *LA-LM*
- All rigidities (TR, LM, PFS): *LA-AR*

- 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.

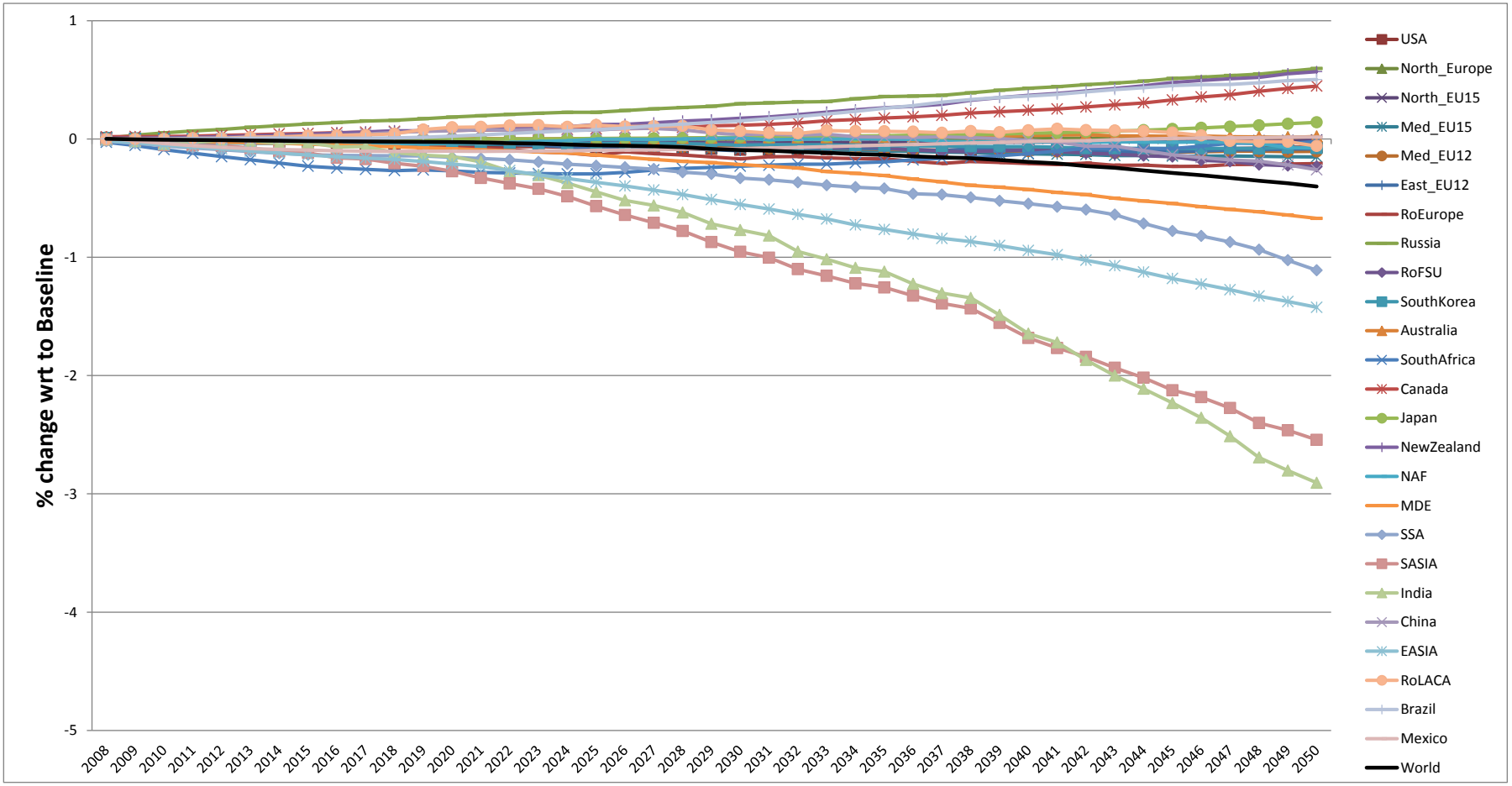
RCP 8.5 impacts on regional GDP with limited adaptation



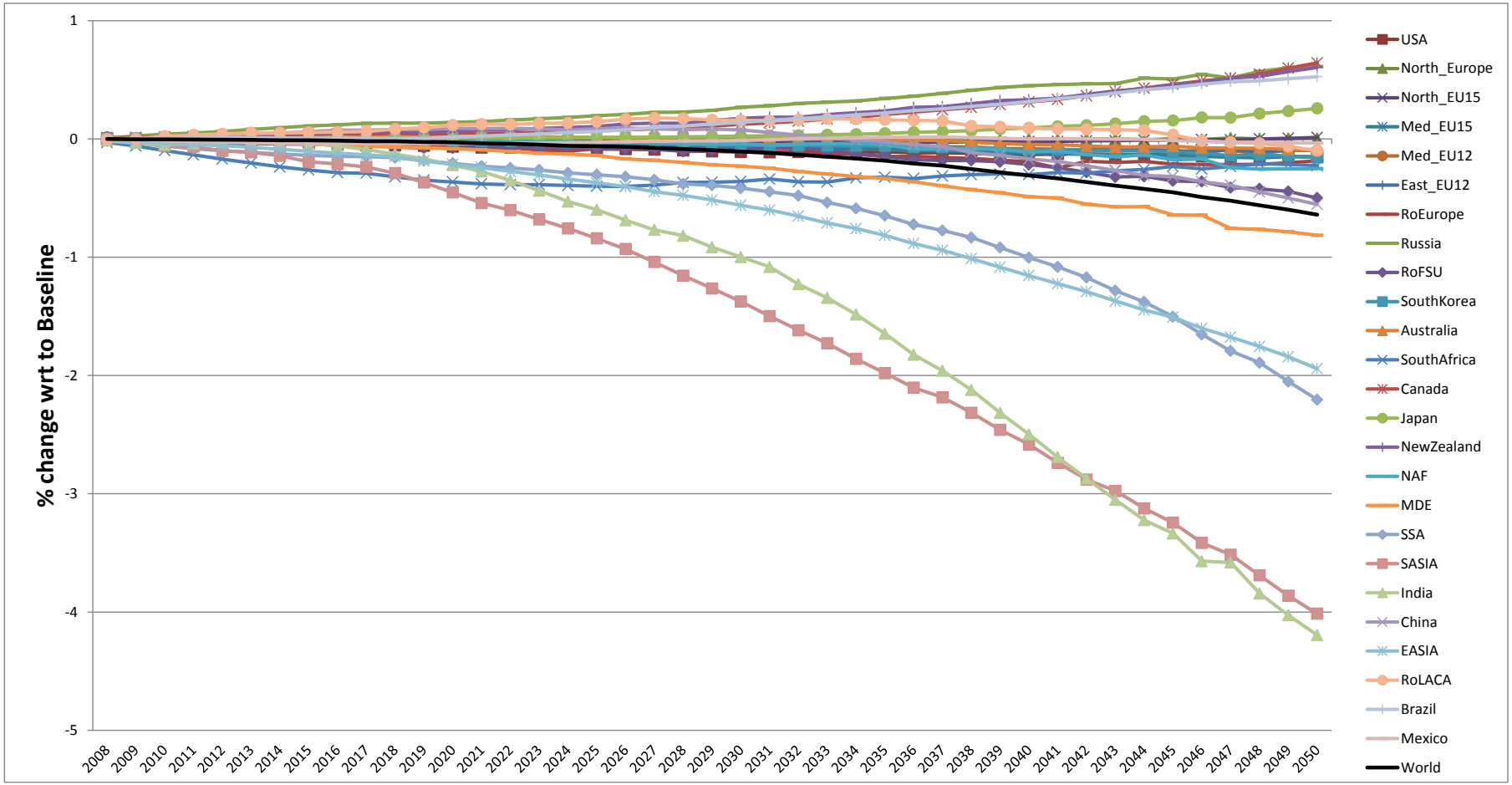
RCP2.6: climate-change impact on macro-regional GDP



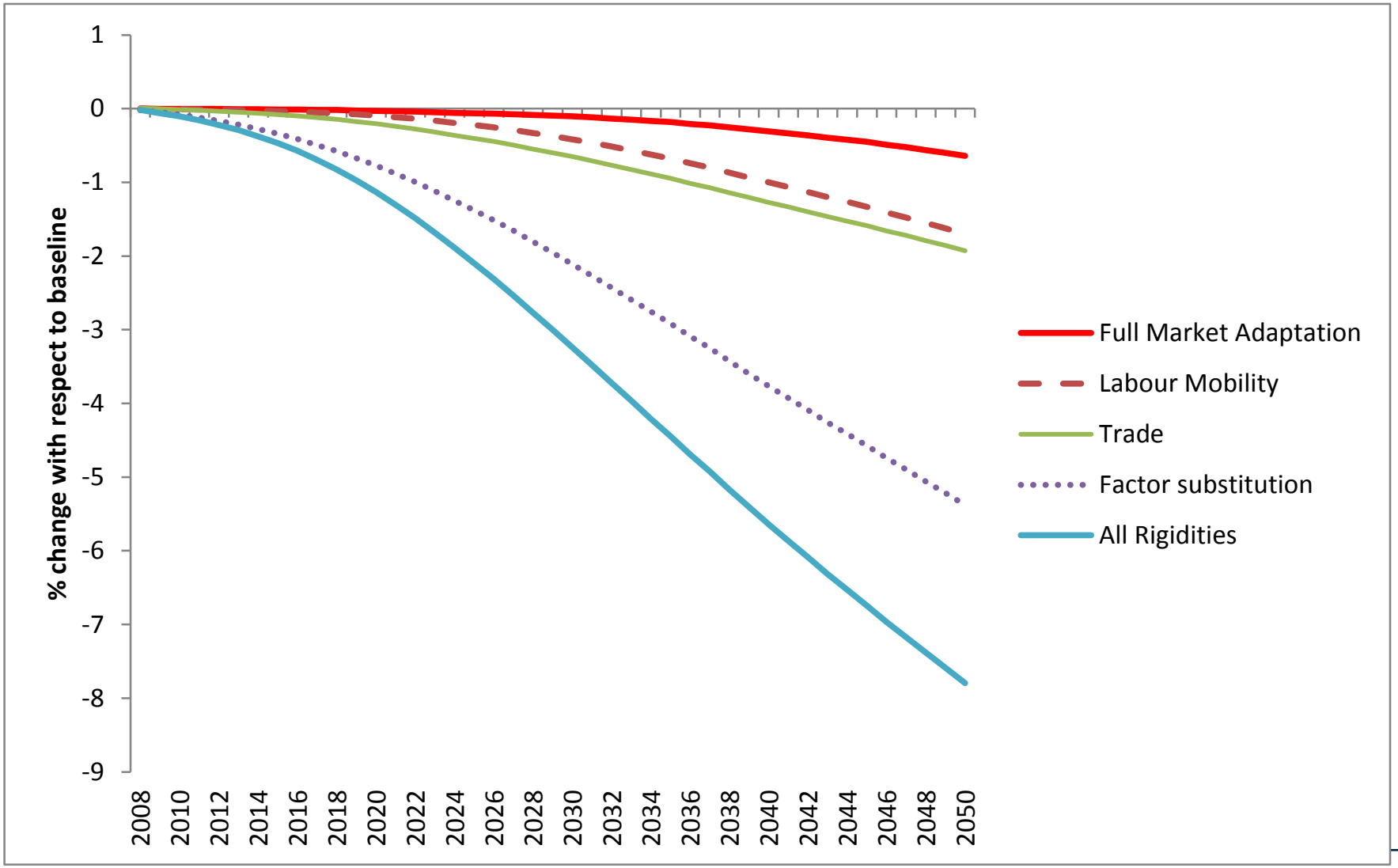
RCP6.0: climate-change impact on macro-regional GDP



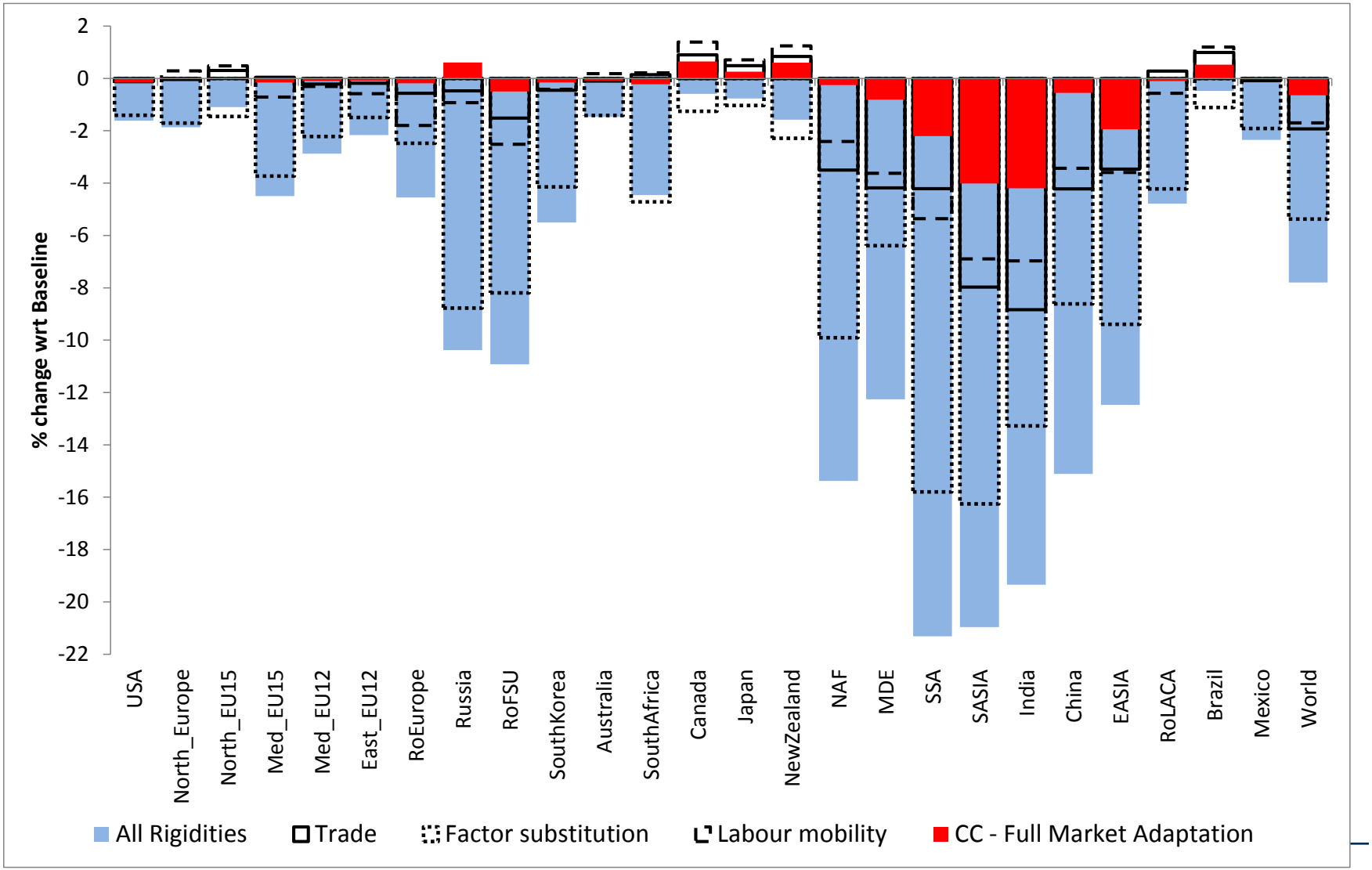
RCP8.5: climate-change impact on macro-regional GDP



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

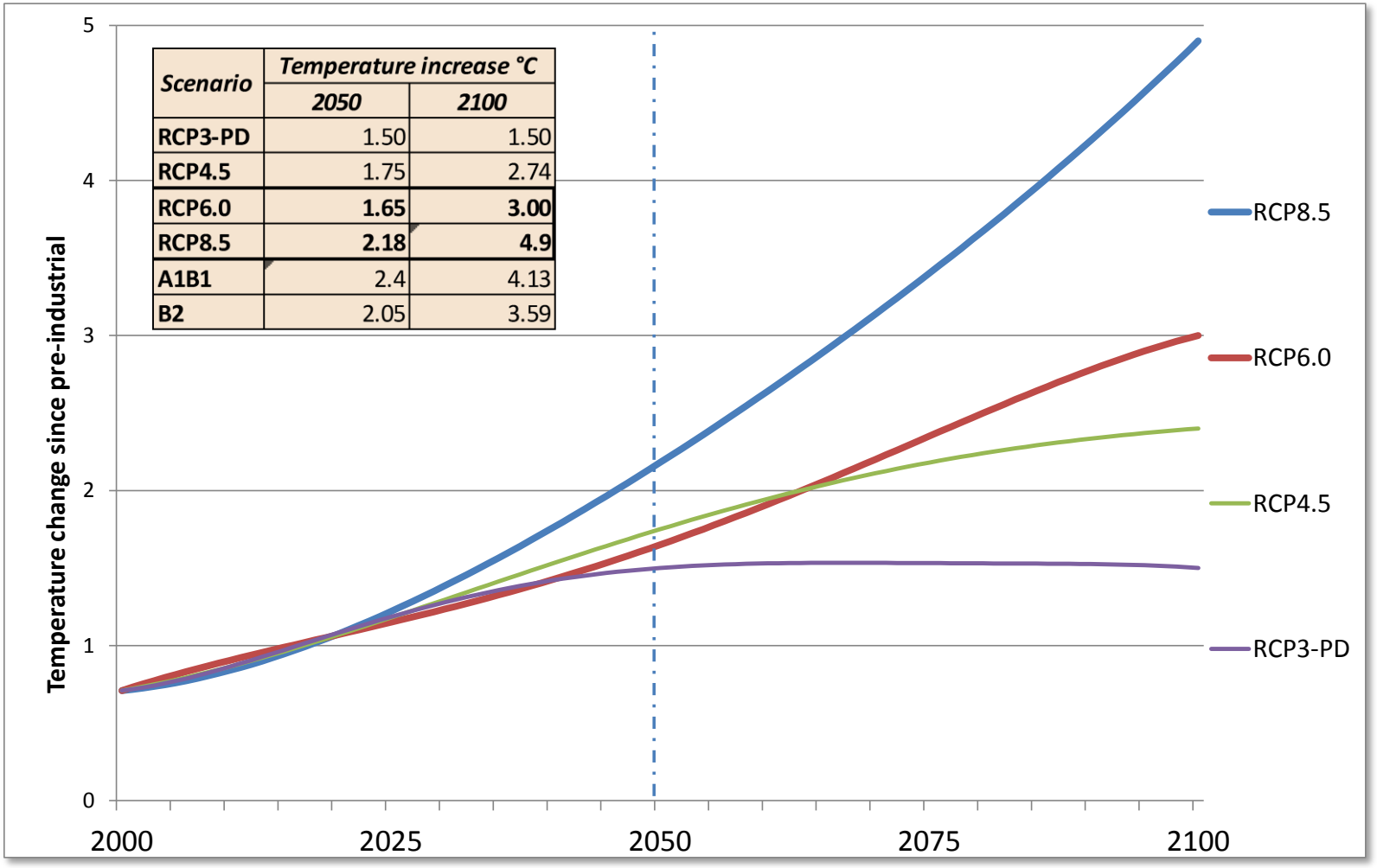


RCP 8.5 impacts on regional GDP with Limited adaptation vs a Full adaptation baseline



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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