



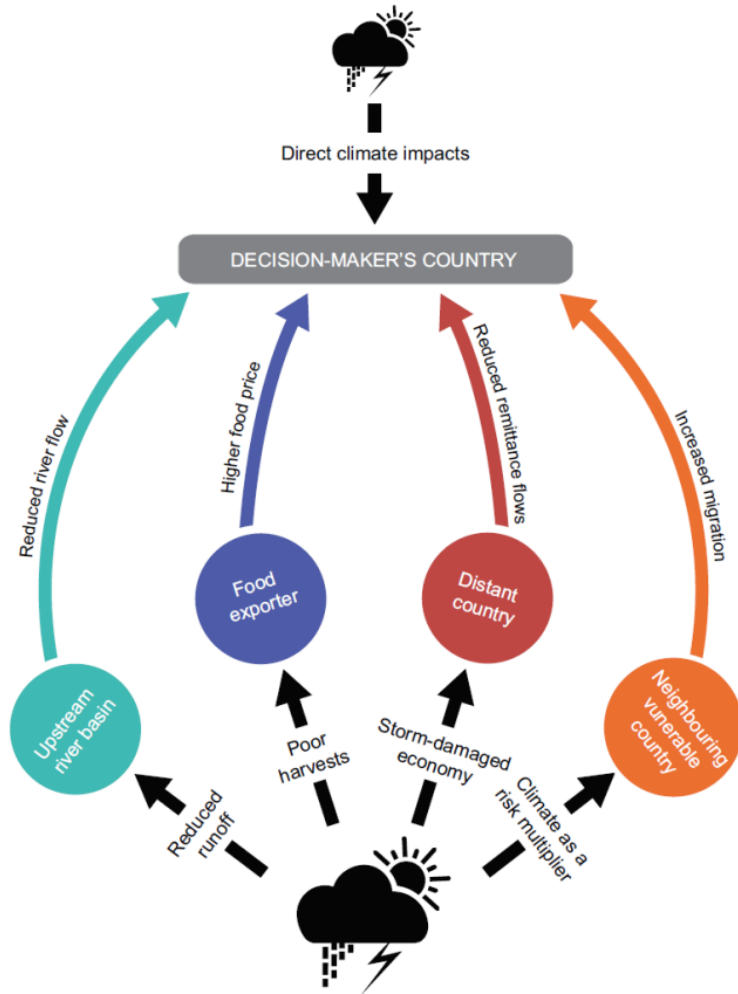
# **A global analysis of heat-related labour productivity losses under climate change - implications for Germany's foreign trade**

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Gabriel Bachner, Andrea Steiner

Klimatag, 25 April 2019  
Vienna, Austria



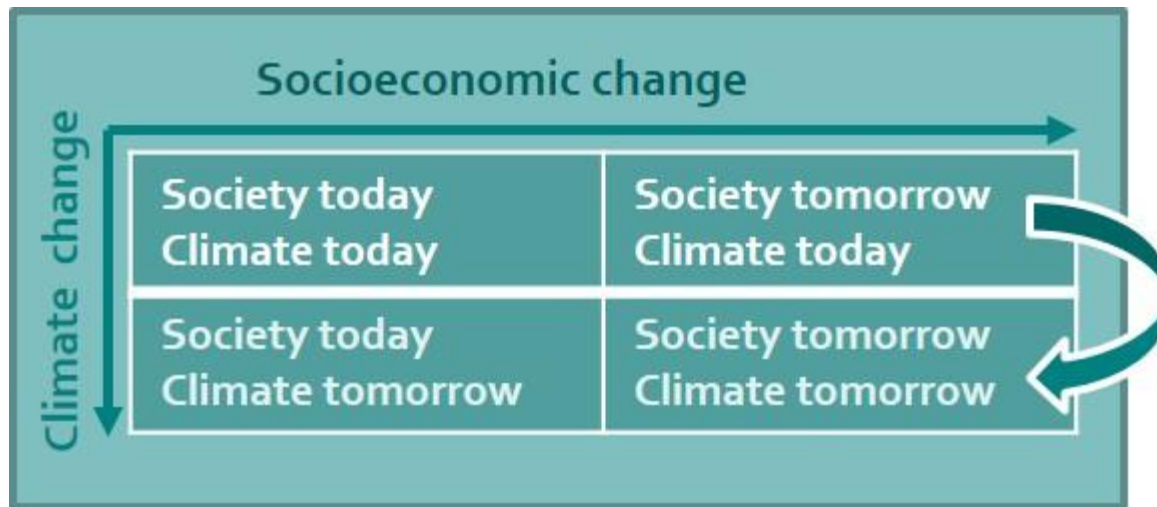
# Transnational transmission of climate change impacts



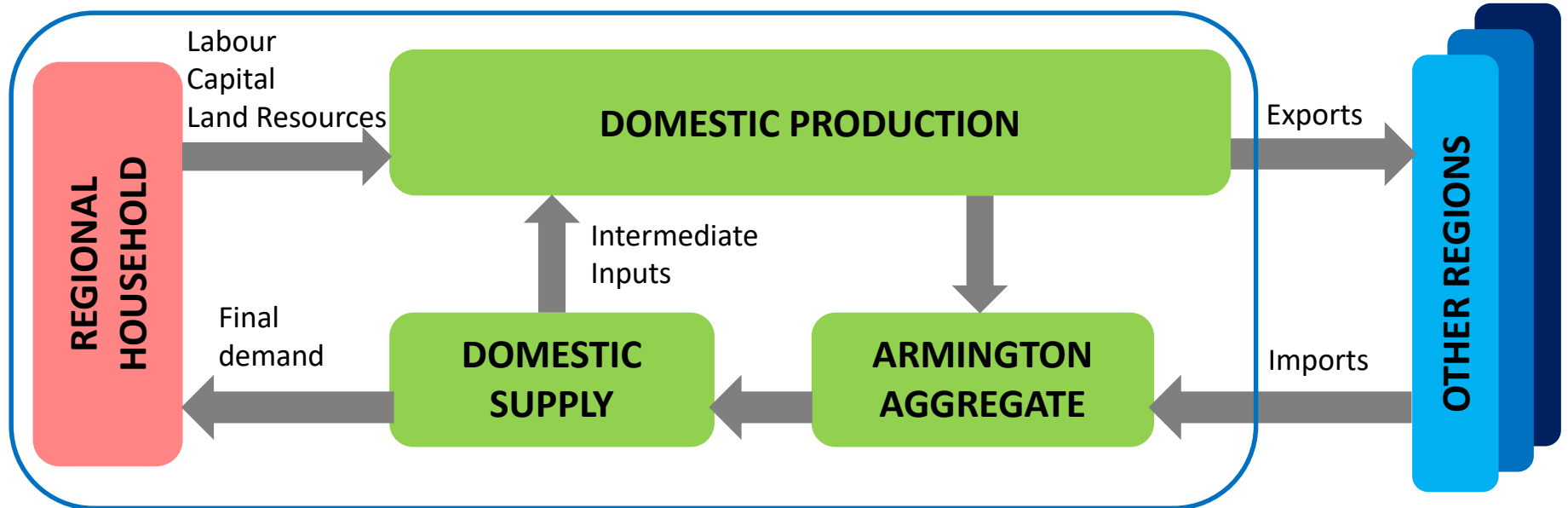
- Climate change impact
  - focus on temperature increase and associated labour productivity losses

- Research question
  - How do these transnational climate change impacts affect the German economy in 2050? How do trade relations alter with CC?

# Macroeconomic Impact Scenario Analysis



# Macroeconomic model: Computable General Equilibrium (CGE) model overview



# Principles of the CGE model

- Database: GTAPv9 (2011)
  - Input-output tables and trade statistics for 163 countries/regions and 67 sectors
  - Aggregated to **23 sectors und 24 regions** based on similarities with respect to climate expositions and trade relations with Germany
- Each **sector** is represented by one company producing with average technology and minimizing costs
- Each **region** is represented by one representative household
  - maximizing utility through consumption, obtaining labour, capital, resource and tax income
- Foreign trade (Armington assumption)
  - Each sector can import and export (at the same time)
  - Goods produced domestically and abroad are not perfectly substitutable (can only be traded-off to a certain degree)

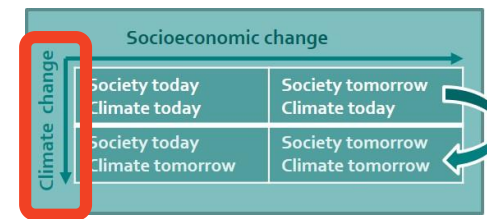
# Model regions

Region cluster	Acronym	Aggregated regions
<b>Europe (EU+)</b>	DEU	Germany
	AUT	Austria
	ITA	Italy
	FRA	France
	BLX	Benelux
	UKI	UK + Ireland
	CEU	Central EU 27 + Switzerland
	NEU	Northern EU 27+ Liechtenstein, Norway and Iceland
	MEU	Mediterranean EU 27
	SEE	South-Eastern EU 27 + Rest of Europe
<b>Outside Europe (non-EU+)</b>	NAM	North America
	ROI	Rest of industrialized countries
	ERA	Eurasian countries
	ECL	Emerging economies- Latin America
	ECA	Emerging economies- Asia+ Israel
	TUR	Turkey
	CHN	China
	IND	India
	SEAT	South-East Asia + Tunisia- Textile industry countries
	SEAE	South-East Asia- Electronical equipment producing countries
	LAM	Latin America (w/o Brazil and Venezuela)
	OIE	Oil exporting countries (OPEC: Middle East and Africa + Venezuela)
	RSEA	Rest of South & South-East Asia (less developed Asian countries)
	AFR	Africa

# Model sector aggregates and according cluster

Sector cluster	Acronym	Sector aggregates in the model
<b>Agriculture, Forestry and Fishery</b>	AGC	Agricultural products -crops
	AGL	Agricultural products -livestock
	FOF	Forestry and Fishery
<b>Extraction sectors</b>	COA	Coal
	OAG	Crude Oil and Natural Gas
	OMN	Other mining
<b>Food, textile and wood industries</b>	FBT	Foodstuffs and feedingstuffs, beverages and tobacco products
	TWL	Textile industry
	WOP	Wood products and paper products, publishing
<b>Machinery and electronic equipment</b>	OME	Machinery, data processing equipment, electronic and optical products
	ELE	Electronic Equipment
	MVT	Motor, Motor vehicles and parts and other Transport Equipment
	ELY	Electricity
	OMF	Other manufacturing
<b>Other industries</b>	P_C	Refined oil products
	CRP	Chemical industry
	NMF	Manufacture of other non-metallic mineral products, precious and non-ferrous metals
	ISM	Manufacture of basic iron and steel and casting and fabricated metal products
<b>Transport</b>	WAT	Transport –Water
	AIT	Transport –Air
	LAT	Transport –Land
<b>Services and construction</b>	SER	Other services and utilities
	CRE	Construction

# Climate Scenarios: Regional Concentration Pathways (RCP)



## Chosen emission scenarios

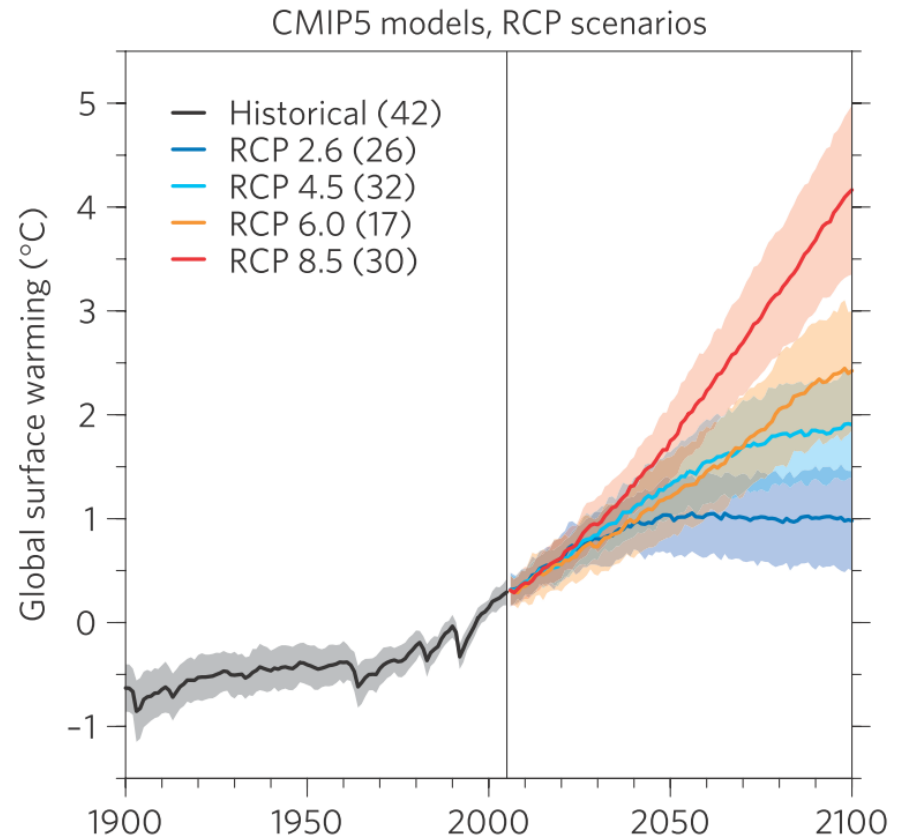
- RCP 4.5
- RCP 8.5

## Chosen global climate models (General Circulation Models)

- HadGEM2-ES, NorESM1-M, IPSL-CM5A-LR, GFDL-ESM2M and MIROC-ESM-CHEM

## Database

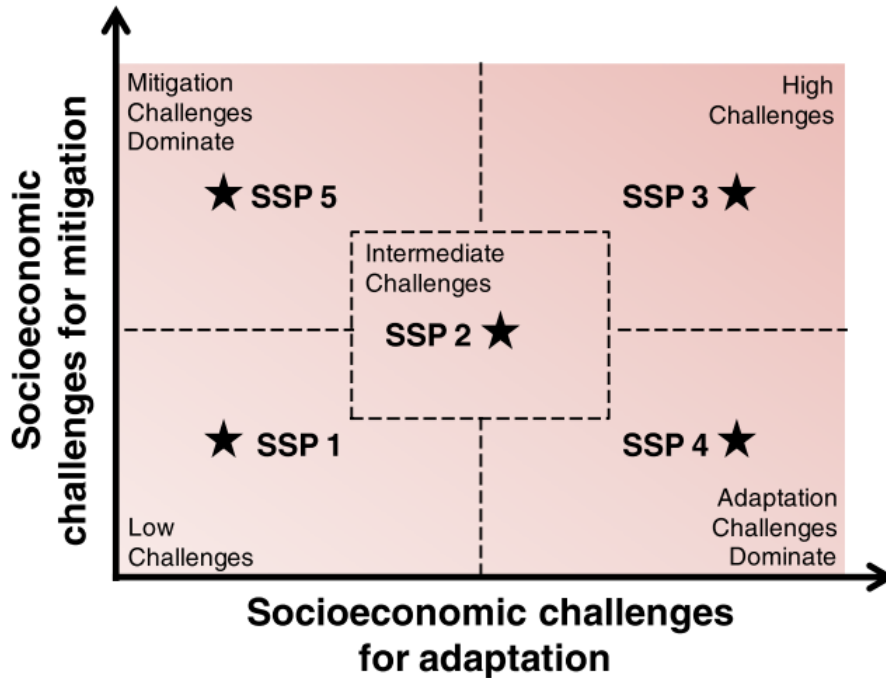
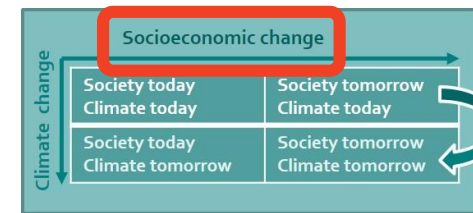
- ISI-MIP (Warszawski et al., 2014)



(Source: Knutti und Sedlacek, 2013)



# Implementation of socioeconomic scenarios: Shared Socioeconomic Pathways (SSP)



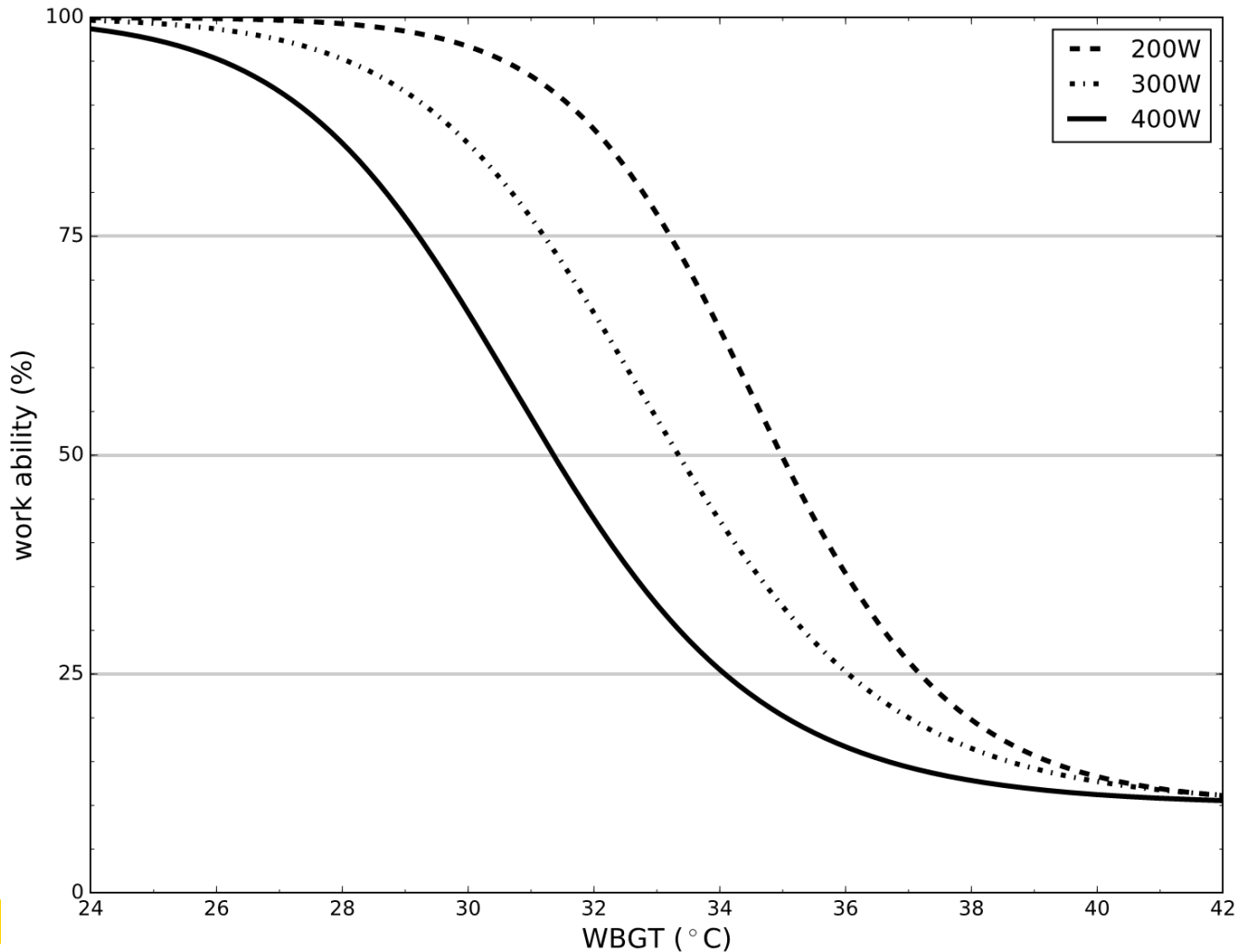
“The SSPs describe *plausible alternative trends in the evolution of society and natural systems* over the 21st century at the level of the world and large world regions. They consist of two elements: a narrative storyline and a set of quantified measures of development. *SSPs are “reference” pathways in that they assume no climate change or climate impacts, and no new climate policies.*” (O’Neill et al., 2014, p.389)

Selected scenarios:

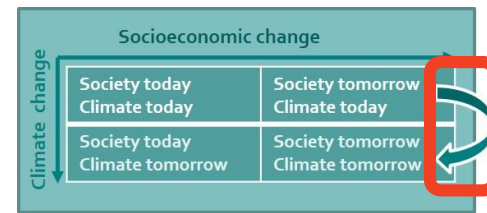
- SSP 1
- SSP 2
- SSP 3

# The Wet Bulb Globe Temperature (WBGT) index and work ability

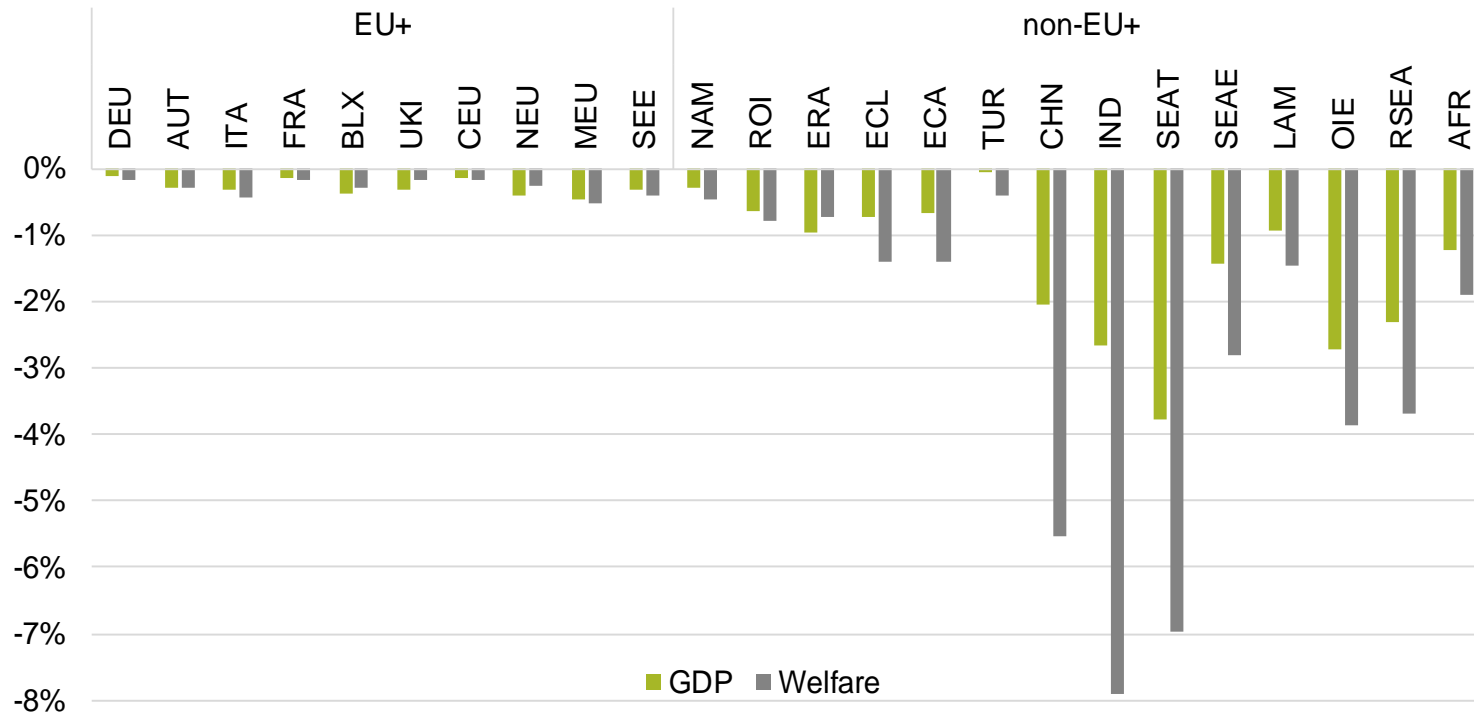
$$\text{Workability}_{\text{Hothaps}} = 0.1 + 0.9 / (1 + (\text{WBGT} / \alpha_1)^{\alpha_2})$$



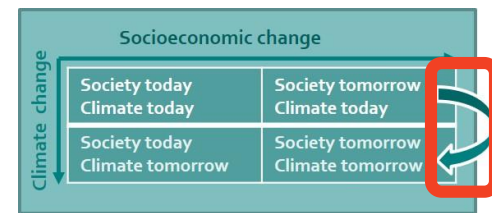
# Climate change impact on macroeconomic indicators in 2050



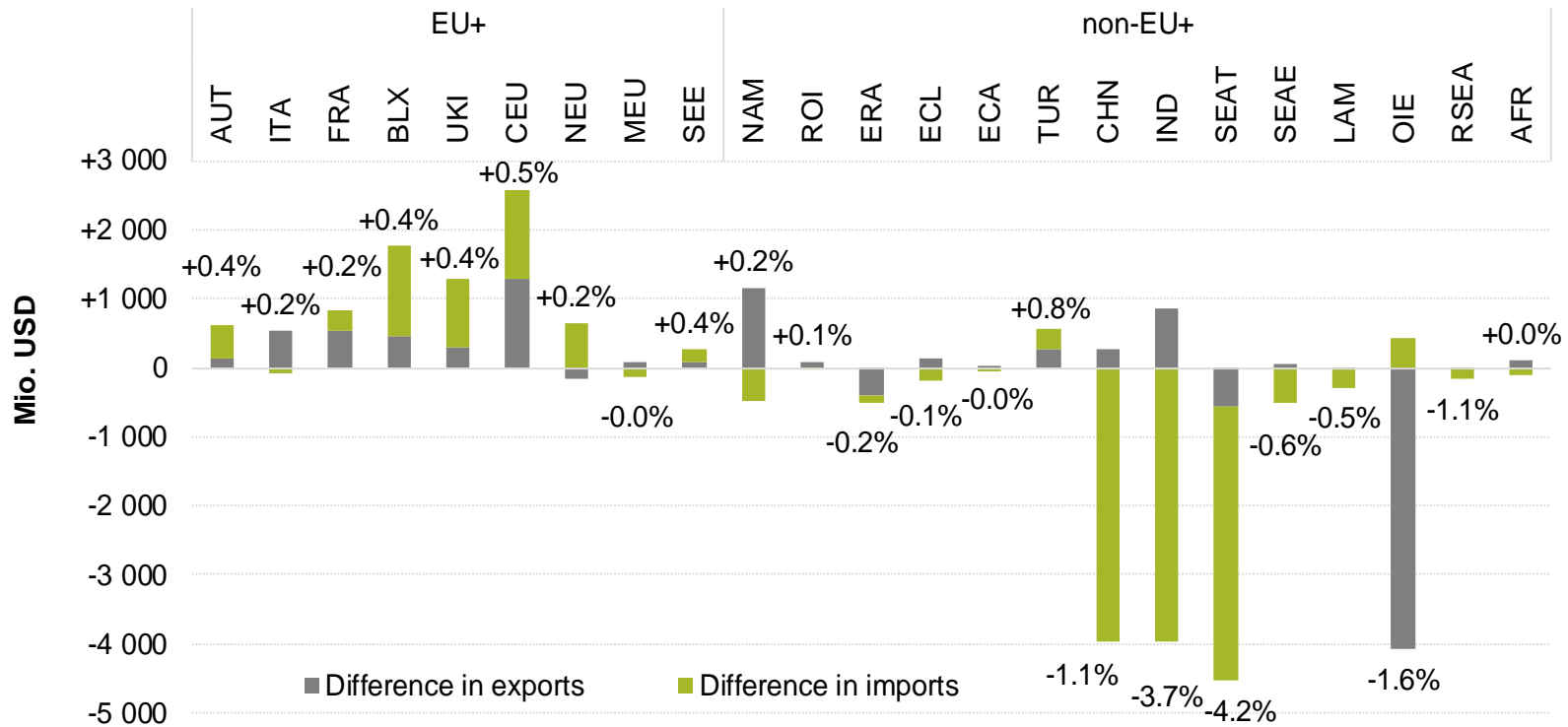
Socioeconomic change - SSP2  
 Climate change - RCP4.5  
 Climate model - HadGEM2-ES



# Climate change impact on Germany's trade balance in 2025

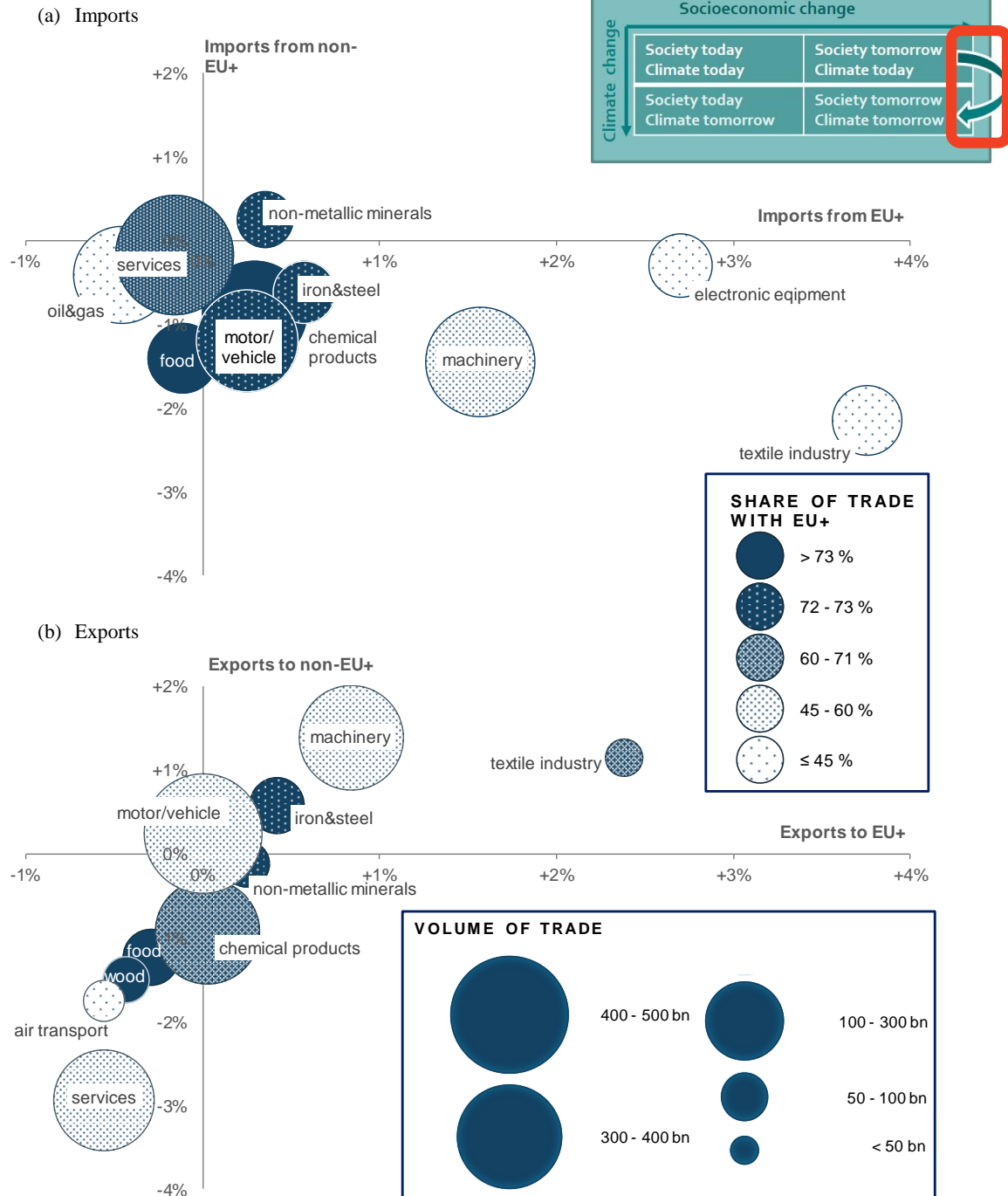


Socioeconomic change - SSP2  
 Climate change - RCP4.5  
 Climate model - HadGEM2-ES

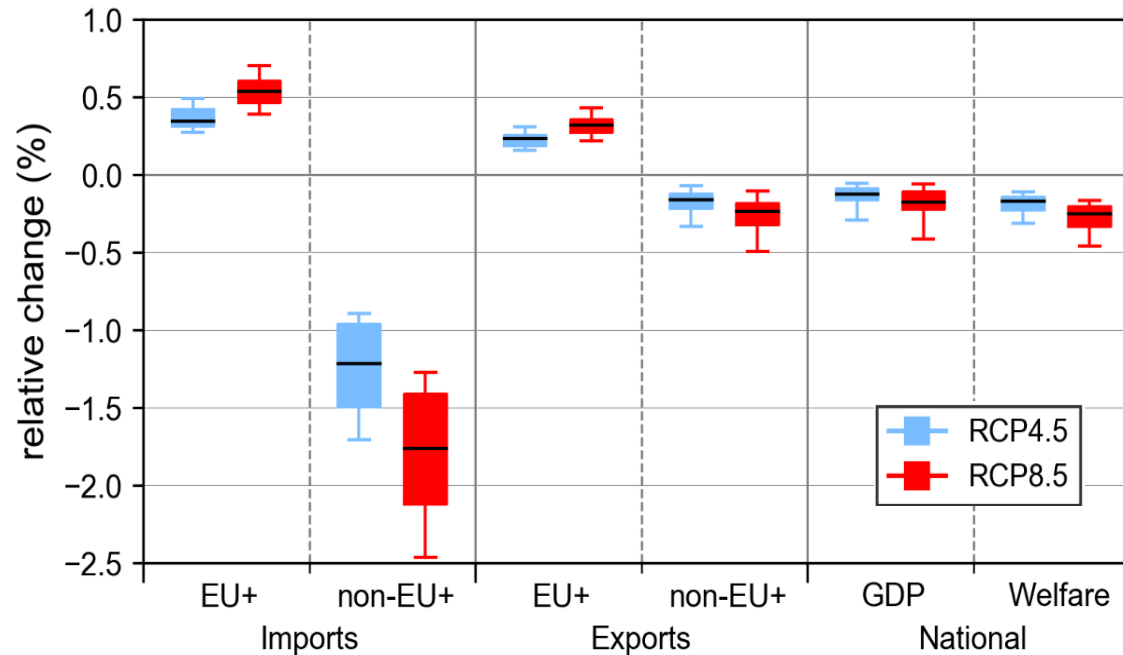
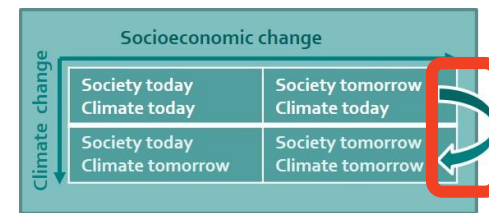


# Climate change impact on Germany's trade by sector

- Imports:
  - shifting imports from non-EU+ to EU+ regions
- Exports:
  - reducing or increasing exports to all regions



# Effects of heat-related labour productivity shocks on Germany



Accounting for

...different **socioeconomic** scenarios (SSP1, SSP2 and SSP3)

...different **emission** scenarios (RCP4.5 and RCP8.5)

...different **climate models** (HadGEM2-ES, NorESM1-M, IPSL-CM5A-LR, GFDL-ESM2M and MIROC-ESM-CHEM)

# Summary

- **Three factors drive results on trade effects**
  - **Regional climate change:** Labor productivity shocks stronger outside of Europe
  - **Trade patterns:** Key trading partners (China, India) in vulnerable regions
  - **Sector specific labor type and sector and region specific labor intensity**
- **Shift of trade patterns due to heat related productivity losses:**
  - Imports decline; exports stay roughly constant to non-EU+ and increase to EU+
  - Less imports from outside of Europe (China, India), only compensated partly by imports from Europe
  - Imports decline strongest for other machinery, textiles, electronic equipment
  - Exports increase in motor vehicles and parts and chemicals, decline in services

# Conclusions

- While an increase in the German trade surplus could be viewed as beneficial from a German perspective, it is important to consider that both German GDP and welfare decline
- Results show that the German economy is relatively better off than other world regions because it is less affected by direct impacts, and can partly compensate losses in trade with regions outside Europe by gains in trade with European regions
- All regions loose in terms of GDP and welfare compared to a baseline scenarios without climate change, higher trade within Europe therefore only displays a comparative but no absolute improvement



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