

EXTREME WEATHER EVENTS AND THE GERMAN ECONOMY – THE POTENTIAL FOR CLIMATE CHANGE ADAPTATION

World Symposium on Climate Change Adaption (WSCCA-2015), Sep 2-4

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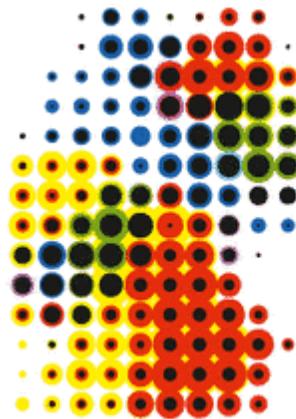
Objective

Model-based analysis of economic effects of adaptation measures in Germany on the aggregate and sector specific level

Main focus:

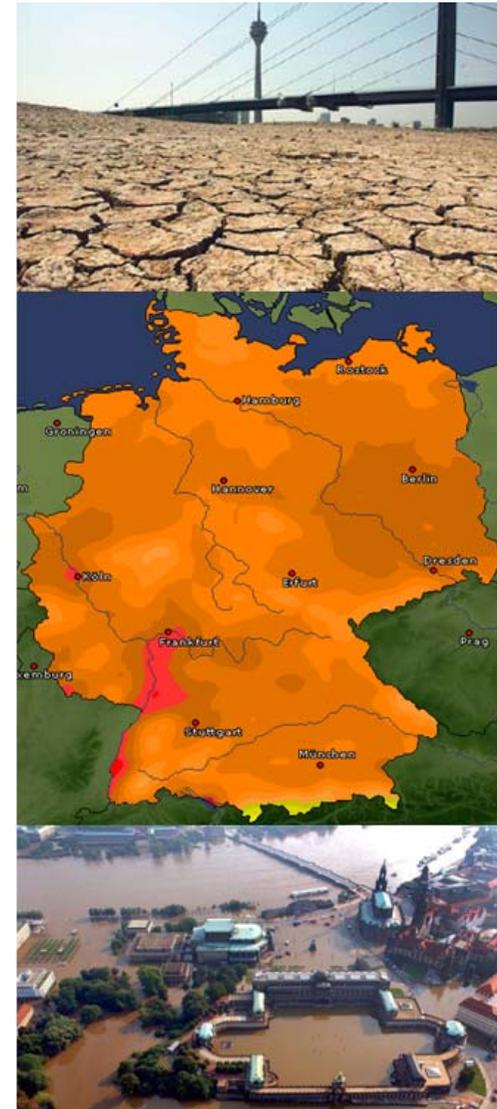
⇒ heat waves

⇒ river floods



Research project:

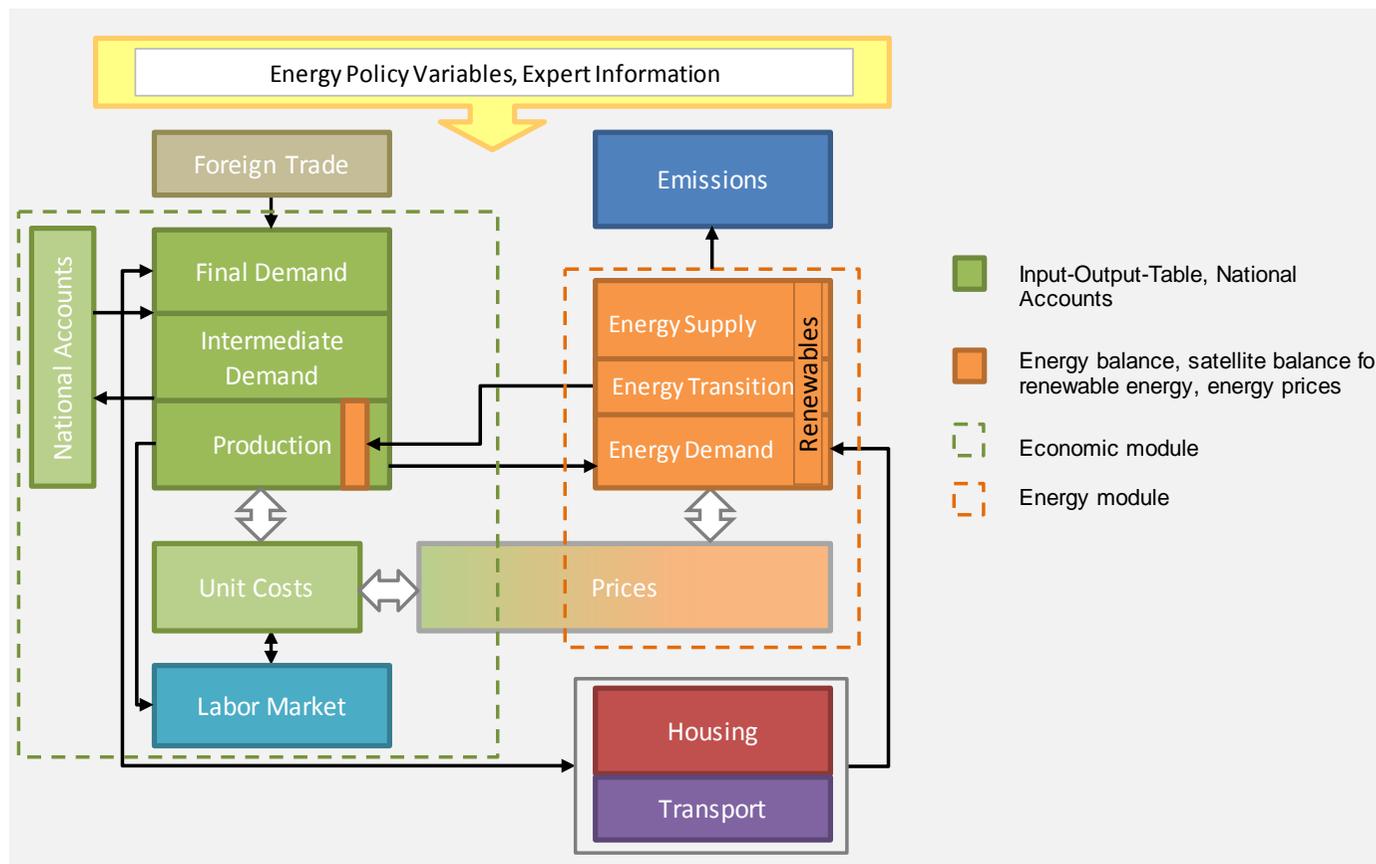
Economics of Climate Change Adaptation (econCCadapt), funded by the German Federal Ministry of Education and Research's (BMBF) Program "Economics of Climate Change" (October 2011 - March 2015)



Modelling tool: PANTA RHEI

PANTA RHEI

- ⇒ input-output-based macroeconomic model
- ⇒ focus on environmental and climate change policies in Germany



Modelling tool: PANTA RHEI

Basic information

- ⇒ input-output-based macroeconomic model
- ⇒ combining economy and environment
- ⇒ focus on environmental and climate change policies in Germany
- ⇒ running until 2050
- ⇒ extended by modules for extreme weather events and adaptation measures

Main method: scenario analysis

- ⇒ effects obtained by comparison of three scenarios
 - reference: economic development without (explicit) climate change
 - **extreme weather (climate) scenario**: heat waves and river floods take place
 - adaptation scenario: extreme weather events and adaptation occur

Extreme weather events: damages from river floods

Possible representation of economic impacts of **flood events** in PANTA RHEI:

- ⇒ damages to residential buildings, plants, equipment and transport infrastructure (capital stock)
- ⇒ production decline due to damages to buildings and equipment as well as flooded fields
- ⇒ rising government spending for civil protection

Extreme weather events: damages from heat waves

Possible representation of economic impacts of **heat waves** in PANTA RHEI:

- ⇒ decline of agricultural production (rise of imported intermediate inputs)
- ⇒ restricted energy production on extremely hot days (shift in electricity import balance)
- ⇒ declining labor productivity on extremely hot days
- ⇒ shift among freight transportation modes from ship to rail and road due to extremely low water

Extreme weather events: timing of events in the modelling

- ⇒ occurrence of flood events every 10 years (with the exception of the last decade from 2041 to 2050 with two such events)
- ⇒ occurrence of heat waves every four years
- ⇒ damage estimates based on data regarding severe river floods and heat waves in the past 15 years

Year	Flood	Heat wave
2013	x	
2021		x
2023	x	
2025		x
2029		x
2033	x	x
2037		x
2041		x
2043	x	
2045		x
2048	x	x

Adaptation measures

Possible adaptation measures in PANTA RHEI:

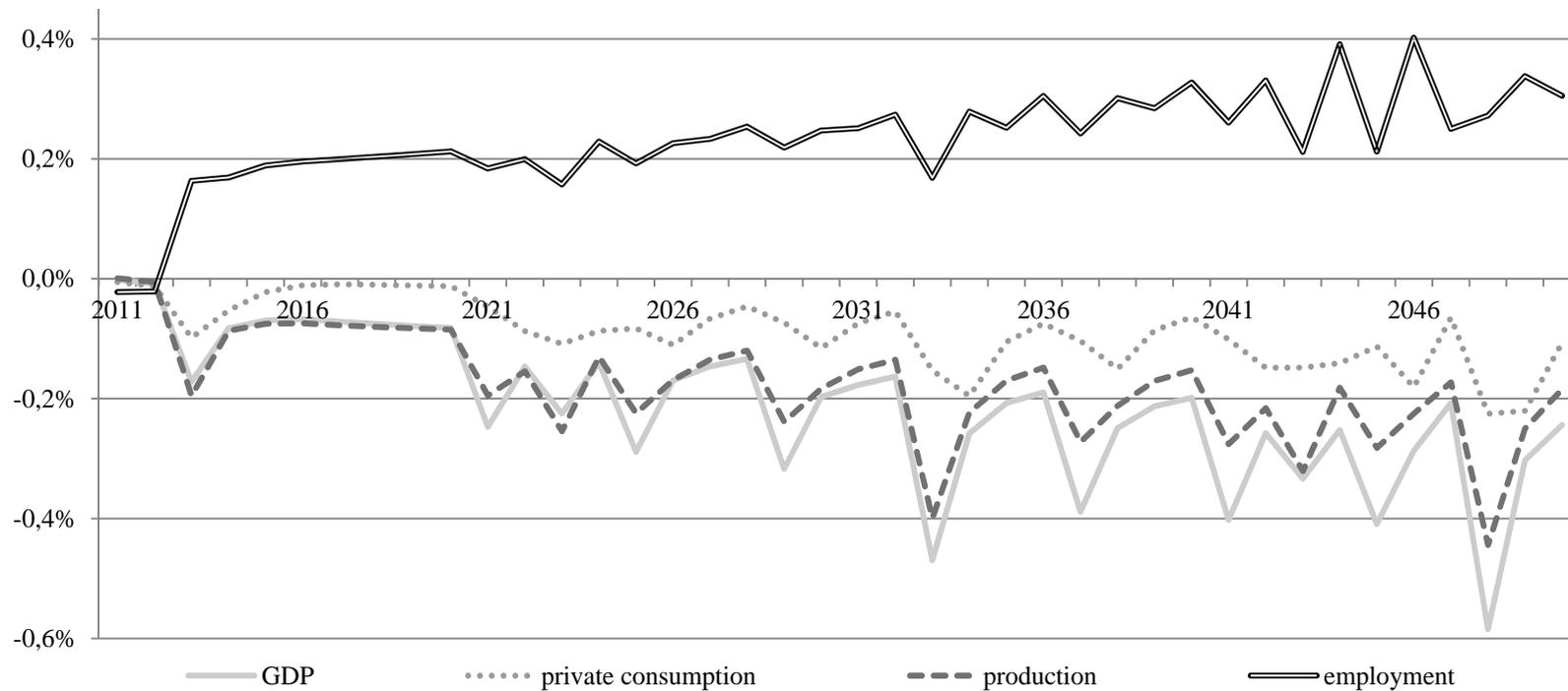
- ⇒ based on published estimates
- ⇒ prevent some damages
- ⇒ costly and gradually implemented, induce economic activity
- ⇒ **river floods**: dike reinforcement, extension of retention areas
- ⇒ **heat waves**: greening of roofs, installation of air-conditioners, installation of cooling towers at power plants

Modelling in PANTA RHEI:

- ⇒ increase of building investments
- ⇒ increase of government transfers
- ⇒ assumption: flood damages no longer occur, productivity decline is prevented, no increasing energy imports in the heat scenario. Other consequences of heat waves remain the same

Results: extreme weather events

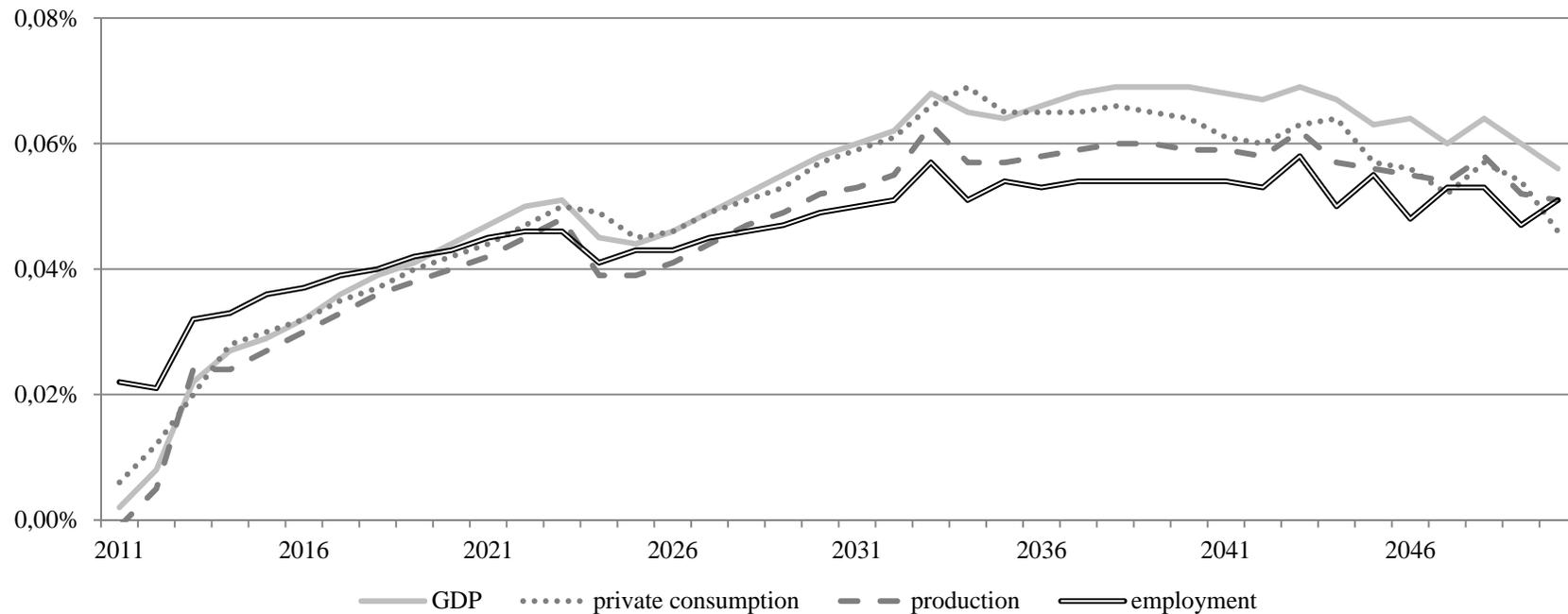
Development of price-adjusted key economic indicators, differences in %, **climate** vs. reference scenario



- ⇒ GDP, production and consumption slightly decrease given climate change
- ⇒ adjustments : capital stock reconstruction, imports supplement domestic production
- ⇒ difference in total employment increases over time

Aggregate results: adaptation measures

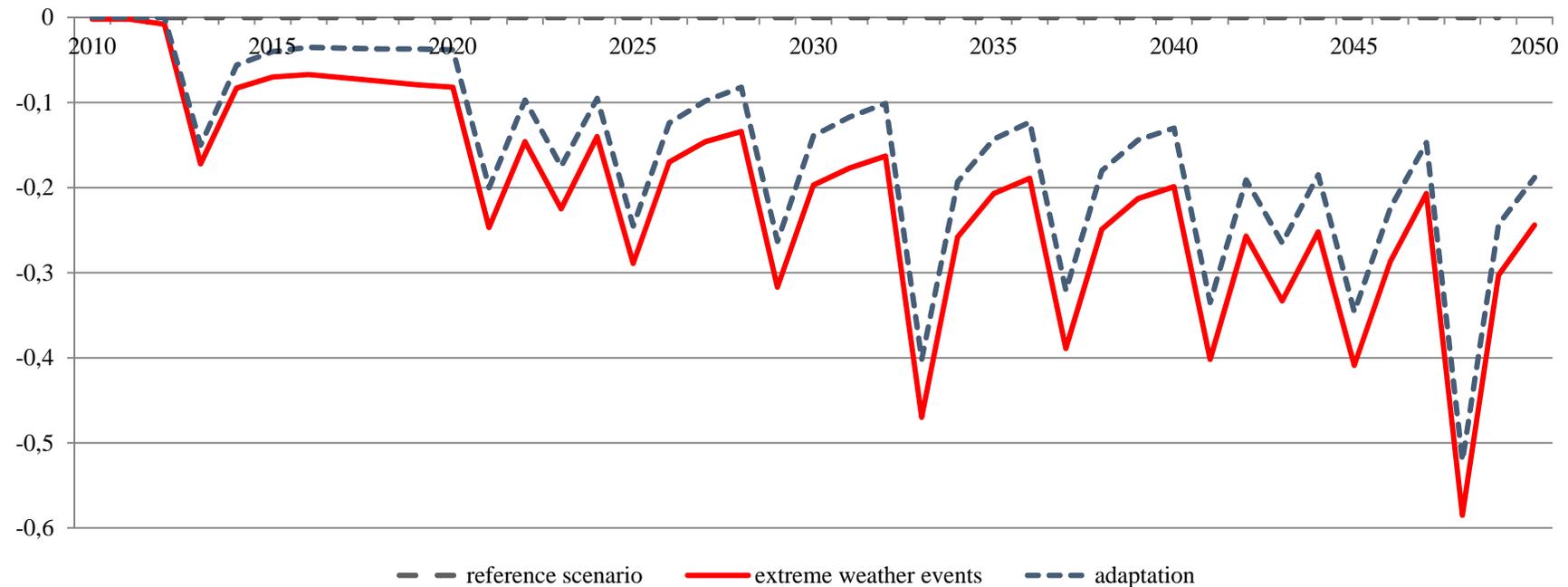
Economic development, differences in %, adaptation vs. **extreme weather scenario**, price adjusted



- ⇒ although adaptation measures are costly, the investments are profitable for the German economy
- ⇒ the positive effect is slightly decreasing in the last decade, because more expensive adaptation measures are taken later

Aggregate results: adaptation measures

Price-adjusted GDP differences in %,
reference vs. **extreme weather** and adaptation scenario



- ⇒ GDP deviations from the reference are smaller in the adaptation scenario compared to the deviations in the climate scenario
- ⇒ Germany's economic situation only slightly less negative in comparison to the reference

Sector-specific results: extreme weather events

Differences in gross value added: **climate** vs. reference scenario

⇒ Absolute deviations (bill. Euros)

- other services and manufacturing
- transport, trade and construction

⇒ Relative deviations (%)

- mining and quarrying and manufacturing
- transport and construction

Sector-specific results: adaptation measures

Differences in gross value added: adaptation scenario vs. **climate scenario**

⇒ Absolute and relative deviations (bill. Euros/%)

- transport: infrastructure more intact, no additional investments required, no need for evacuation of materials etc.
- +
- all other sectors: smaller losses and bigger gains
 - manufacturing: lower damages to buildings and production sites (retention areas, dikes), diminished necessity for disposal of rubble or destroyed machinery
 - mining and quarrying: more demand for intermediate inputs from manufacturing
 - energy sector: less utility companies reduce energy production (cooling towers)
 - agriculture: less damages, payments for retention areas
 - construction: investments in dikes, roofs, air-conditioning

Conclusions: modelling results

- ⇒ total economic effects of heat waves and river floods are expected to become slightly (but increasingly) negative in Germany
- ⇒ conservative assessment, since other extreme weather events not modelled
- ⇒ the most negatively affected sector (gross value added) is manufacturing
- ⇒ some sectors (e.g. transport) profit from climate change
- ⇒ adaptation measures diminish the negative aggregate effects
- ⇒ residual damages remain, mitigation strategies may be preferred
- ⇒ due to adaptation negative effects on the sectors decrease, whereas the positive effects increase

Conclusions: general insights

- ⇒ the data situation is still unsatisfactory
- ⇒ input-output-based macro models need to be improved for better analysis of extreme weather events
- ⇒ an aggregate view is incomplete, because of heterogeneous impacts across German regions
- ⇒ global consequences of climate change such as shifts in foreign trade need to be taken into account



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Sector-specific perspective

Gross value added on the sectoral level in 2014, in bill. Euros

industry	GVA in 2014 in bill. Euros
agriculture, forestry and fishing	20
mining and quarrying	7
manufacturing	535
energy and water	71
construction	114
trade	250
hotels and restaurants	45
transport and communication	150
financial services	92
other services	1252

- ⇒ The structure of value added dominated by other services, manufacturing and trade
- ⇒ The economy relies on a strong industrial core (vulnerability of high/tech sites!) intertwined with other sectors (IO)

Sector-specific results: extreme weather events

Gross value added: differences in bill. Euros cumulated in 10-year intervals, climate vs. reference scenario

industry	2011-2020	2021-2030	2031-2040	2041-2050
agriculture, forestry and fishery	0.1	0.0	0.4	0.3
mining and quarrying	-0.1	-0.3	-0.3	-0.3
manufacturing	-3.6	-14.0	-13.6	-22.2
energy and water supply	-0.3	-0.6	-0.8	-1.0
construction	1.7	3.1	5.0	5.4
trade	2.0	3.8	6.6	7.8
hotel and restaurant industry	-0.2	-0.7	-0.9	-1.3
transport and communication services	6.5	9.1	10.3	10.7
financial intermediation	0.6	0.8	1.3	1.3
other services	-2.5	-12.6	-16.5	-25.2

- ⇒ the strongest negative absolute deviations from the reference occur in the sectors other services and manufacturing (biggest sectors)
- ⇒ the strongest positive absolute deviations from the reference occur in the sectors transport, trade and construction

Sector-specific results: extreme weather events

Gross value added: average deviation per decade in %, climate vs. reference scenario

economic sectors	2011-2020	2021-2030	2031-2040	2041-2050
agriculture, forestry and fishery	0.07%	0.01%	0.11%	0.09%
mining and quarrying	-0.17%	-0.31%	-0.27%	-0.28%
manufacturing	-0.07%	-0.22%	-0.19%	-0.28%
energy and water supply	-0.04%	-0.09%	-0.13%	-0.16%
construction	0.14%	0.21%	0.28%	0.29%
trade	0.08%	0.12%	0.18%	0.20%
hotel and restaurant industry	-0.04%	-0.14%	-0.14%	-0.17%
transport and communication services	0.43%	0.48%	0.43%	0.38%
financial intermediation	0.06%	0.07%	0.10%	0.09%
other services	-0.02%	-0.08%	-0.09%	-0.11%

- ⇒ the strongest negative relative deviations from the reference occur in the sectors mining and quarrying and manufacturing
- ⇒ the strongest positive relative deviations from the reference occur in the sectors transport and construction

Extreme weather events: aggregate results

Differences in bill. Euros (or 1000 employees) cumulated in 10-year intervals, climate vs. reference scenario

aggregate indicators	2011-2020	2021-2030	2031-2040	2041-2050
consumption of private households	-3.4	-12.2	-16.7	-23.5
production	-36.4	-92.6	-115.4	-165.7
capital stock	-70.3	-85.5	-71.9	-95.8
investments	-2.4	-4.7	-5.9	-11.0
employment	605.3	215.9	126.4	36.0
disposable income	0.0	-0.2	-0.2	-0.3

Average deviation per decade in %, climate vs. reference scenario

aggregate indicators	2011-2020	2021-2030	2031-2040	2041-2050
consumption of private households	-0.02%	-0.08%	-0.11%	-0.14%
production	-0.08%	-0.18%	-0.20%	-0.26%
capital stock	-0.05%	-0.06%	-0.04%	-0.05%
investments	-0.05%	-0.09%	-0.11%	-0.18%
employment	0.15%	0.06%	0.04%	0.01%
disposable income	-0.02%	-0.10%	-0.12%	-0.17%

Sector-specific results: adaptation measures

Gross value added: average deviations per decade in bn. Euros, adaptation vs. reference scenario

industry	2011-2020	2021-2030	2031-2040	2041-2050
agriculture, forestry and fishery	0.2	0.1	0.5	0.6
mining and quarrying	0.0	-0.1	-0.1	-0.2
manufacturing	-0.2	-9.4	-7.6	-15.6
energy and water supply	0.0	-0.2	-0.2	-0.3
construction	3.2	7.1	12.3	15.0
trade	2.7	5.0	8.4	9.7
hotel and restaurant industry	0.1	-0.4	-0.4	-0.8
transport and communication services	0.7	2.2	2.5	2.9
financial intermediation	0.8	1.2	1.9	1.9
other services	-0.6	-6.0	-6.6	-13.1

Sector-specific results: adaptation measures

Gross value added: average deviations per decade in %, adaptation vs. reference scenario

aggregate indicators	2011-2020	2021-2030	2031-2040	2041-2050
private consumption	0.00%	-0.03%	-0.04%	-0.09%
production	-0.05%	-0.14%	-0.14%	-0.20%
capital stock	0.03%	0.21%	0.44%	0.58%
investments	0.04%	0.06%	0.12%	0.10%
employment	7.32%	-1.14%	-0.47%	-0.09%
disposable income	0.05%	0.04%	0.06%	0.02%

- ⇒ comparing the deviations between the adaptation scenario and the reference with the deviations between the climate scenario and the reference reveals stronger positive and weaker negative effects in all sectors (with the exception of transport)
- ⇒ considering relative deviations, the construction sector gains the most, followed by trade; still most negatively affected are mining & manufacturing

Adaptation measures: aggregate results

Differences in bill. Euros (or 1000 employees) cumulated in 10-year intervals, adaptation vs. reference scenario

aggregate indicators	2011-2020	2021-2030	2031-2040	2041-2050
private consumption	0.5	-4.9	-6.6	-14.2
production	-24.0	-69.7	-82.3	-129.4
capital stock	4.9	37.5	67.7	87.7
investments	2.1	3.3	6.8	5.9
employment	745.6	-248.7	-142.2	-20.8
disposable income	8.6	7.5	14.2	5.8

Average deviation per decade in %, adaptation vs. reference scenario

aggregate indicators	2011-2020	2021-2030	2031-2040	2041-2050
private consumption	0.00%	-0.03%	-0.04%	-0.09%
production	-0.05%	-0.14%	-0.14%	-0.20%
capital stock	0.03%	0.21%	0.44%	0.58%
investments	0.04%	0.06%	0.12%	0.10%
employment	7.32%	-1.14%	-0.47%	-0.09%
disposable income	0.05%	0.04%	0.06%	0.02%



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