GWS SPECIALISTS IN EMPIRICAL ECONOMIC RESEARCH

ECONOMIC EFFECTS OF ADAPTING CRITICAL INFRASTRUCTURE

Case No 2a

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Research innovations from this case study

- **Contribution to the research questions 1 and 3**:
  - ⇨ 1. to develop and test an approach to assess climate change risks that covers both the short-term need for ‘adjusting’ within the current societal framework and the possible need for long-term and large-scale efforts of ‘societal transformation’;
  - ⇨ 3. to develop and test an applicable framework for analyzing how societal change can affect local climate change vulnerabilities, how to conduct an integrated assessment of the combined effect of potential climate and societal changes, and how to better understand the socio-economic consequences involved in local climate change adaptation;
- This case study takes into account the **socio-economic dynamic development**.
- Socio-economic developments (as outlined in the respective SSP scenarios) can enhance or mitigate the risk from climate change, because socio-economic development **will affect exposure and vulnerability negatively or positively**.
- Population density, infrastructure, built environment, cultural assets change under different scenarios. Under the SSP framework, different pathways for population, investment and therefore state of infrastructure etc. can be selected.
- Thus, we take into account the future socio-economic scenarios for a **meaningful risk assessment regarding the impacts on critical infrastructure from climate change**.

Considering a changing society: SSP scenarios

- SSP scenarios represent different **global socioeconomic developments for the 21st century**.
- They are intended to capture policy-relevant ranges of socio-economic trajectories into the future.
- On the one hand, the SSPs serve as a basis for deriving the **Representative Concentration Pathways (RCP)**, and on the other hand for characterizing the **adaptation and mitigation challenges**.

- We take the assumptions from the SSP and develop **a set of consistent scenarios on a national level** for Germany
- The scenarios **differ in several details**: population development, economic development, energy use, modes of transport…
- The macroeconometric model PANTA RHEI will be used to calculate the economic effects of climate-related **impacts on infrastructure** in the context of different societal developments according to the SSPs and **the economic effects of adaptation**.
- Critical Infrastructures to focus on in this case study: **Transport, Energy, Health**

German national socio-economic scenarios based on SSPs

	trend	stability	dynamic
Description	Business-as-usual, comparable to SSP 2	Comparable to SSP 1	most similar to SSP 5, but without a comparable focus on the use of fossil fuels
Population development (annual net migration as of 2020)	200,000		300,000
GDP growth rate (annual)	1.3 % up to 2020 1.0 % up to 2025 0.8 % as of 2026		1.7 % up to 2020 1.3 % up to 2025 1.2 % as of 2026
Energy and climate targets	Delayed target achievement	Targets achieved	Targets missed
Transport	Delayed target achievement	Largely GHG-neutral in 2045, transport performance bounded	High transport performance, climate and environmental targets subordinated
Land use (Reduction of land-take for settlements and transport 30 ha minus x per day by 2030)	Target missed	Target achieved	Rather increase in land take

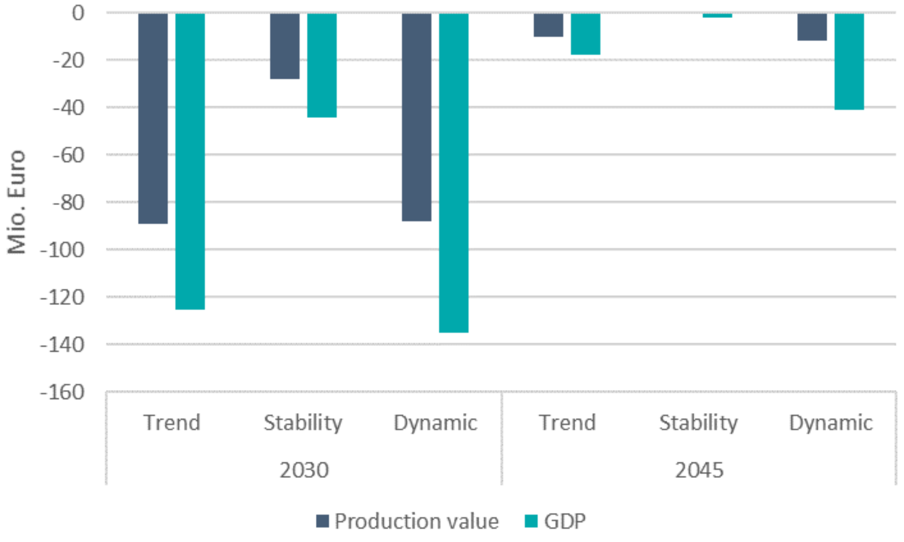
Source: Lutz et al. (2019)

- The socio-economic scenarios affect vulnerability and exposure and thus **climate change risk.**

Modeling and results: Energy

- <u>Scarcity of cooling water for thermal power plants due to heat / drought</u>:
  - ⇨ Increase in hot days and rising temperatures may affect the generation capacity of thermal power plants, especially in summer for the middle and end of the century
  - ⇨ Reduced efficiency → **higher wholesale prices** and price volatility
  - ⇨ **Adaptation**: e.g., water-efficient cooling systems, but role of thermal power plants decreasing against the background of the energy transition in Germany, therefore not considered

Changes in Production Value and GDP due to temperature-induced reduction in hard-coal fired electricity generation for the years 2030 and 2045 in Mio. Euro, real values



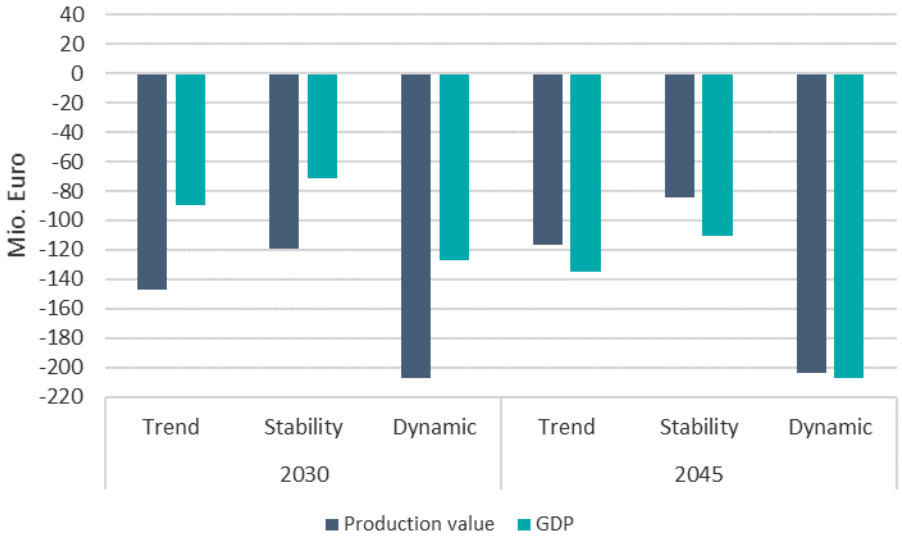
<u>Results:</u>

- Reduced electricity generation → decreasing production value in the energy sector
- Increased price level for electricity → the production value in other economic sectors decreases, as electricity is used as an input
- Decreasing consumption expenditures of households and the government, also reduced investment activities
- Reduced exports, increasing imports
- Due to the **energy mix assumed in the SSP scenarios**, the Dynamic scenario is affected more strongly, as more conventional energy is used here.

Modeling and results: Transport

- Closed highways due to high precipitation, leading to detours and interruption of production:
  - ⇨ The detours lead to both **increased time consumption and additional mileage**. The time delay for freight traffic can lead to noticeable effects on the economy.
  - ⇨ Truck drivers need **more time** to deliver their goods; **More truck drivers** are needed.
  - ⇨ The detours driven lead to **additional fuel consumption**, which in turn leads to **increasing prices** in the transportation sector.
  - ⇨ Production processes in the industry must be interrupted. As a result, **stock levels are changing**.

Changes in Production Value and GDP due to the closure of a highway for the years 2030 and 2045 in Mio. Euro, real values



Results:

- Increased price level for transportation → the production value in other economic sectors decreases, as transportation is used as an input
- Decreasing consumption expenditures of households and the government, also reduced investment activities
- Due to the **different transport performance in the SSP scenarios**, the Dynamic scenario is affected more strongly, as more transportation is done via road transport.

Modeling and results: Transport

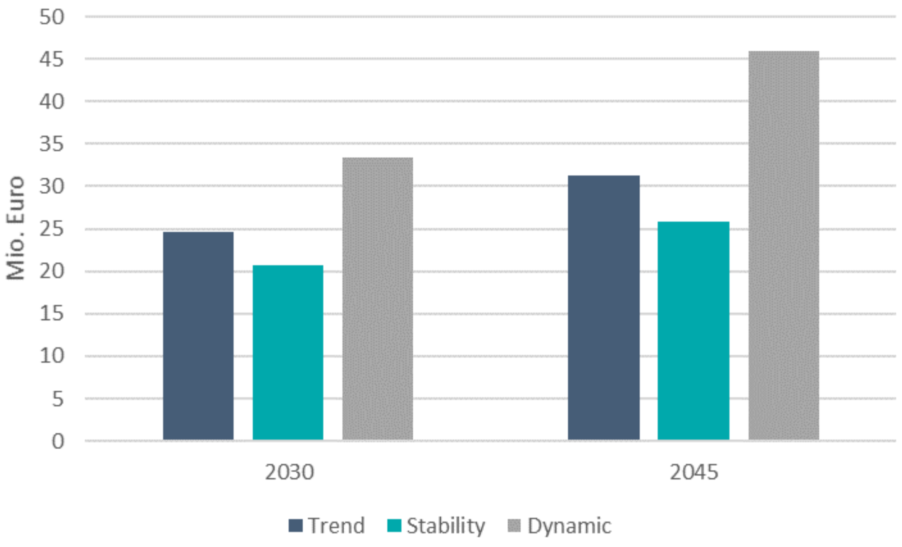
- <u>Closed highways due to high precipitation, leading to detours and interruption of production</u>:
  - ⇨ **<u>Adaptation</u>**: Capacity increase of roads' drainage systems is the most appropriate adaptation measurement to precipitation increase → **Reduced damages** and positive effect of additional **investment**

Estimations for additional costs of drainage system depending on % increase of drainage capacity (in million EUR/year)

100% increase of capacity	50% increase of capacity	20% increase of capacity
33,6	16,8	6,7

Source: Alvater et al. 2012

Changes in GDP value due to the implementation of the adaptation measure "Increasing drainage capacity" for the years 2030 and 2045 in Mio. Euro, real values (Differences between a scenario with CC <u>and</u> adaptation to a scenario with <u>only</u> CC)



<u>Results:</u>

- **Annual investment** for a 20% increase in capacity: 6.7 million EUR
- Likewise, **reduction of the original damages** by 20%.
- Compared to the scenario with climate change, **overall positive effect on the GDP** in the damage years (2030 and 2045) as well as in all other years
- **Depending on the SSP scenario**, adaptation **pays off sooner or later** and results in an overall **positive or negative net-effect** (to be analyzed)

Conclusion

- **Policy relevance**:
  - ⇨ Quantifying and visualizing the impacts of CC on different SSP scenarios → Providing **a meaningful risk assessment regarding the impacts of CC on critical infrastructure**
  - ⇨ Exemplification of the **adaptation challenges regarding different SSP** scenarios

- **Scientifically important findings**:
  - ⇨ Calculation and quantification of a possible and plausible **corridor of results** to better understand and estimate the effects of different adaptation measures

- **Improving the impact chain method**:
  - ⇨ Linking the impact chain method to macroeconomic modelling
  - ⇨ Providing the quantitative values for the qualitative strands of the impact chains
  - ⇨ Discovering new effects and further intermediate impacts that have not yet been encountered in the qualitative development of the impact chains

Thank you for your attention!

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