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Vulnerability to fuel price increases: Socio-spatial patterns in Germany

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This work

- Report commissioned by **Agora Verkehrswende** (Stark et al., 2023)
- My work (as a freelance subcontractor): **development of a spatial indicator of vulnerability to fuel price increases** in Germany

Vulnerability to fuel price increases: a topic in the public and political debate

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- Motor fuel prices: **liable to increase** because of:
  - policy measures (CO_2 taxes, ETS)
  - geopolitical events (e.g., wars)

- Usually the gist of the discussion is: „***Some people would suffer*** *from it, therefore the we should* ***ditch the measure altogether / cut prices*** *across the board*“

- Alternative / **better framing**:
  - how many are vulnerable?
  - **who are they** / where they live?
  - what **targeted measures** would help?

Image: Patrice Calatayu

Vulnerability to fuel price increases: a research topic

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- **„Transport poverty“: a broad phenomenon**, with multiple dimensions (Lucas et al., 2016):

1. Mobility poverty

2. Transport affordability
   a) related to public transport costs
   b) related to the costs of car ownership & use
      i. **Vulnerability to fuel price increases**

1. Accessibility poverty

2. Exposure to transport externalities

Vulnerability to fuel price increases: a research topic

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- Seminal early work on „oil vulnerability“ from Australia (Dodson & Sipe, 2007)
- Since the 2010s, **growing number of indicators of the affordability of car use** proposed in a European context
- Little research on Germany to date
  (e.g. Büttner et al., 2013 for Munich metropolitan area)

Table 1 Overview of indicators of the affordability of car use in the European context

		Unit of analysis		
		Household/ individual	Sub-national spatial unit	Country
Type of indicator	**Adaptation of (domestic) energy poverty indicators**	• Nicolas et al. (2012) [*] • Lovelace & Philips (2014) [*# +] • Cochez et al. 2015 [*# +] • Berry et al. (2016) [*] • Verry et al. (2017) [*] • Mattioli et al. (2018) [*] • Madre and Bussière (2020) [*]	• Nicolas et al. (2012) [*] • Lovelace & Philips (2014) [*# +] • Cochez et al. 2015 [*# +]	
	'Forced car ownership' indicators	• BMVBS (2012) [*] • Mattioli (2017) [*] • Curl et al. (2018) [*]	• Carroll et al. (2021) [# +]	
	Composite indicators	• Berry (2018) [*]	• Sustrans (2012) [# +] • Büttner et al. (2013) [# +] • Mattioli et al. (2019) [# +]	• OpenExp 2019) [*]

Legend * Survey data; # Modelled data; + Census data

(Mattioli et al., 2023)

Vulnerability (to fuel price increases): 3 dimensions

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- Conceptual framework adopted for many composite indicators of vulnerability to fuel price increases (Arico, 2007; Büttner et al., 2013; Leung et al., 2018; Mattioli et al., 2019; 2023)
- Vulnerability = "*the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt*" (Adger, 2006, p.268-270)

Exposure: "nature & degree to which system experiences stress"	Cost burden of fuel; car use & car ownership (proxies)
Sensitivity: "degree to which system is modified or affected by perturbations"	Economic resources; Poverty or deprivation metrics (proxies)
Adaptive capacity: "ability to evolve to accommodate (stress) & expand range of variability with which it can cope"	Accessibility to key services by modes alternative to the car (i.e., the opposite of car dependence)

(High) Vulnerability = (high) exposure + (high) sensitivity + (low) adaptive capacity
= high car use + low income + high car dependence

A composite indicator of vulnerability to fuel price increases for Germany

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- Vulnerability index: weighted sum of four standardized indicators

Table 1: Indicators for three dimensions of vulnerability to fuel price increases in Germany

Dimension	Indicator	Spatial unit	Data source	Year	Weight
Exposition	Motorisation rate	Municipality	KBA	2022	33.3%
Sensitivity	Disposable income of private households (per capita)	*Kreis*	Federal Statistical Office of Germany	2020	16.7%
	Median gross earnings for full-time employees	*Gemeindeverband*	Federal Employment Agency	2021	16.7%
Adaptive capacity	Public transport departures per day and per settlement area	Municipality	*Agora Verkehrswende*	2022	33.3%

Findings: 3 dimensions

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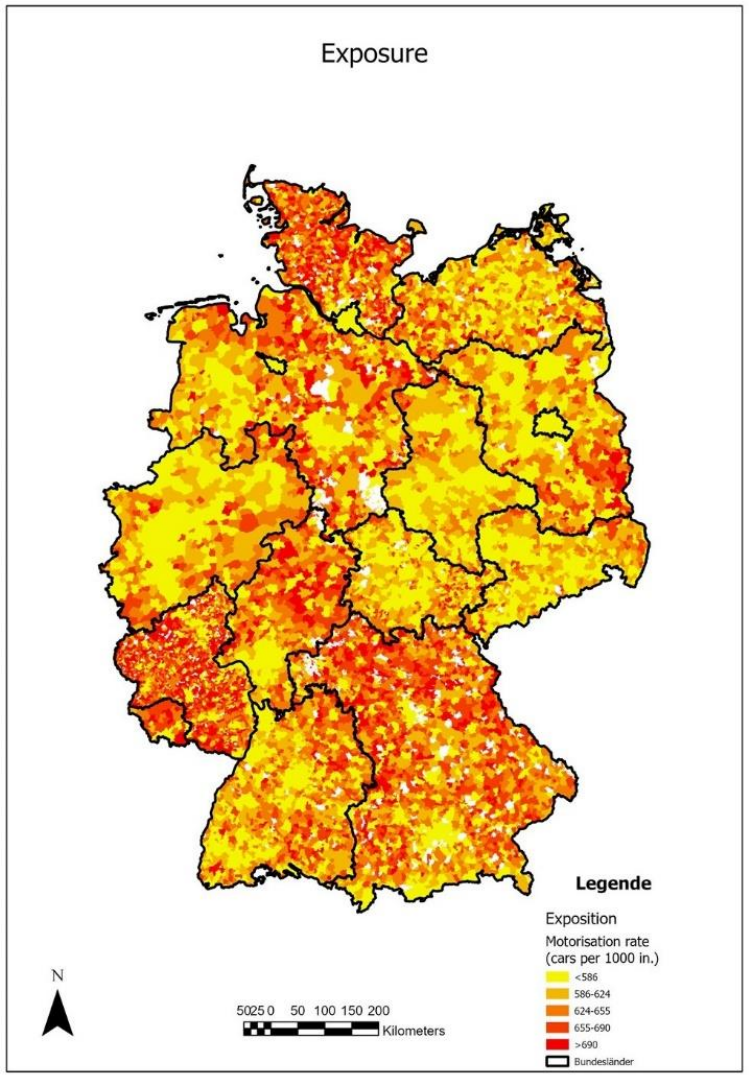

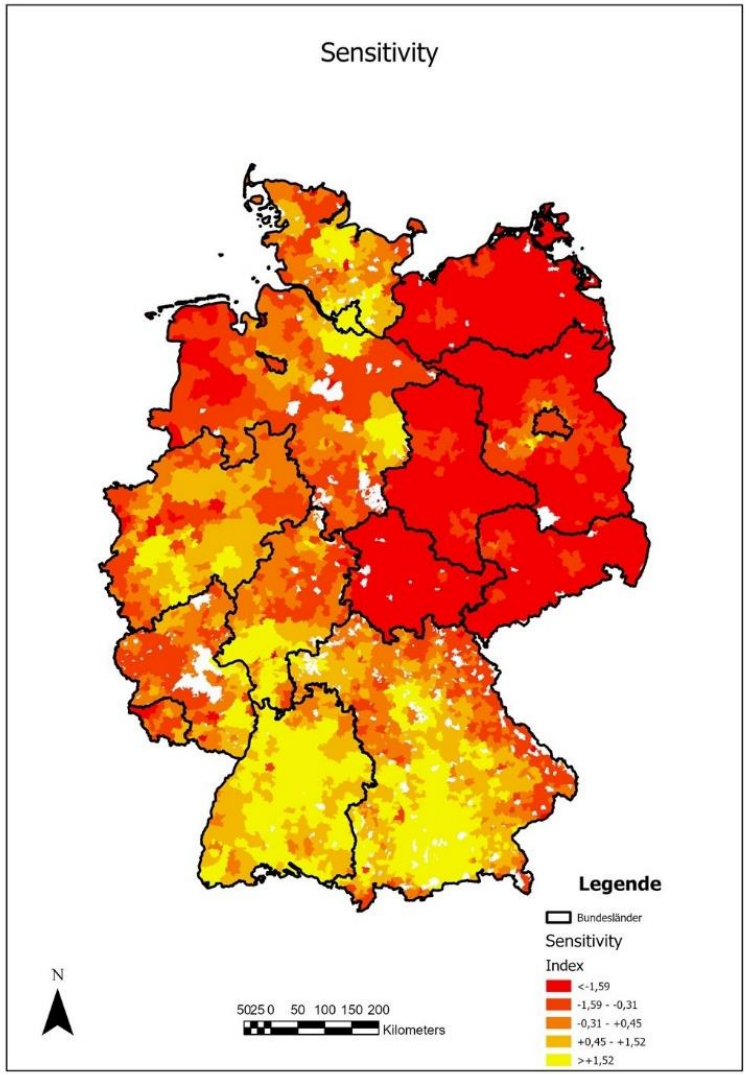

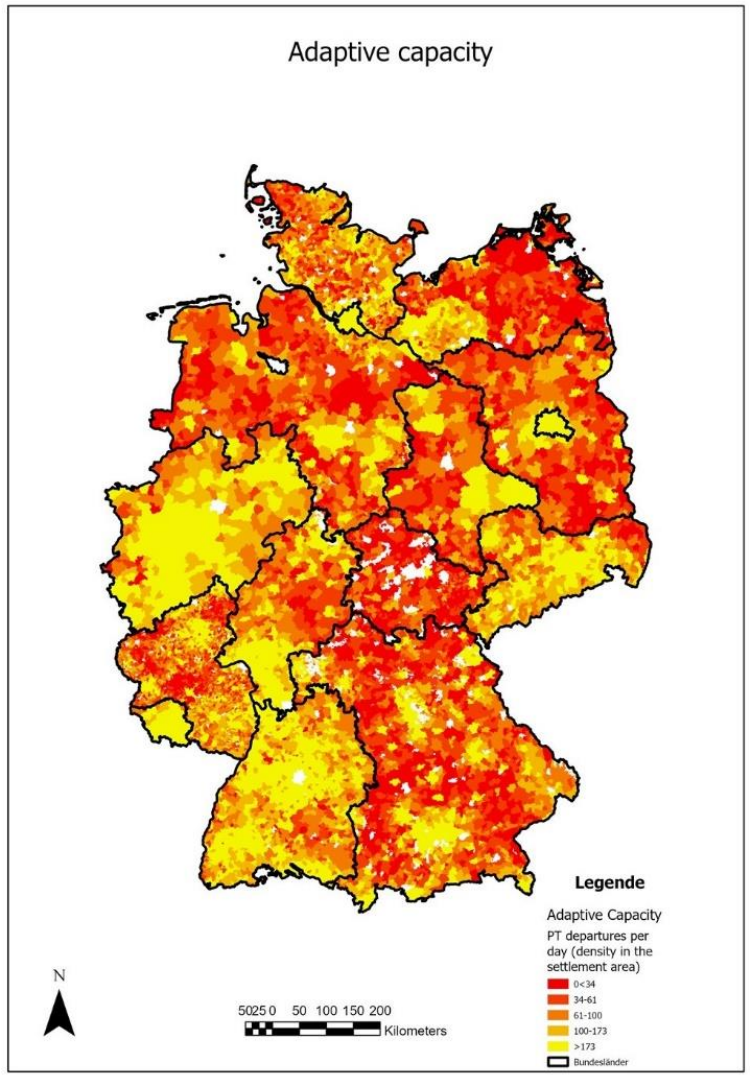

Findings: composite indicator

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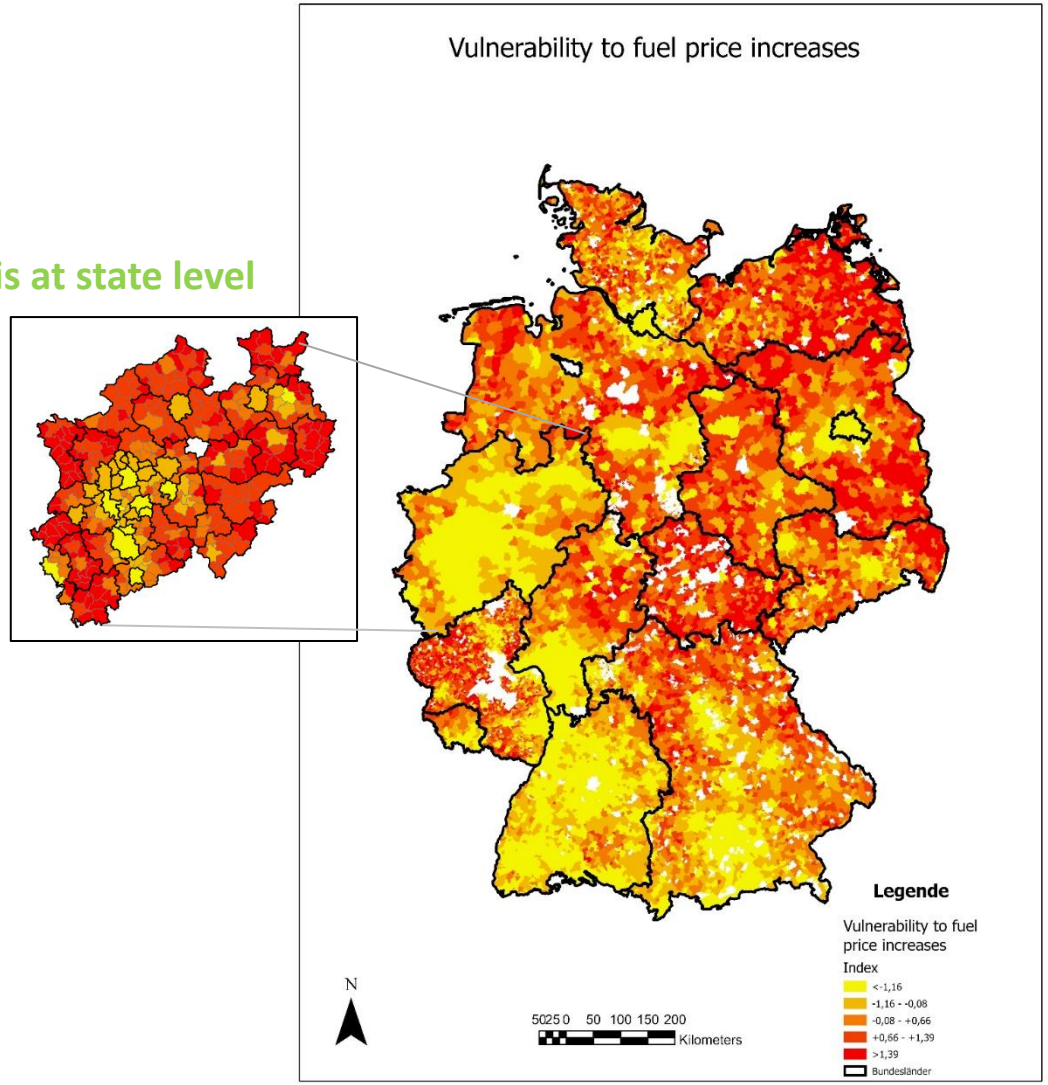
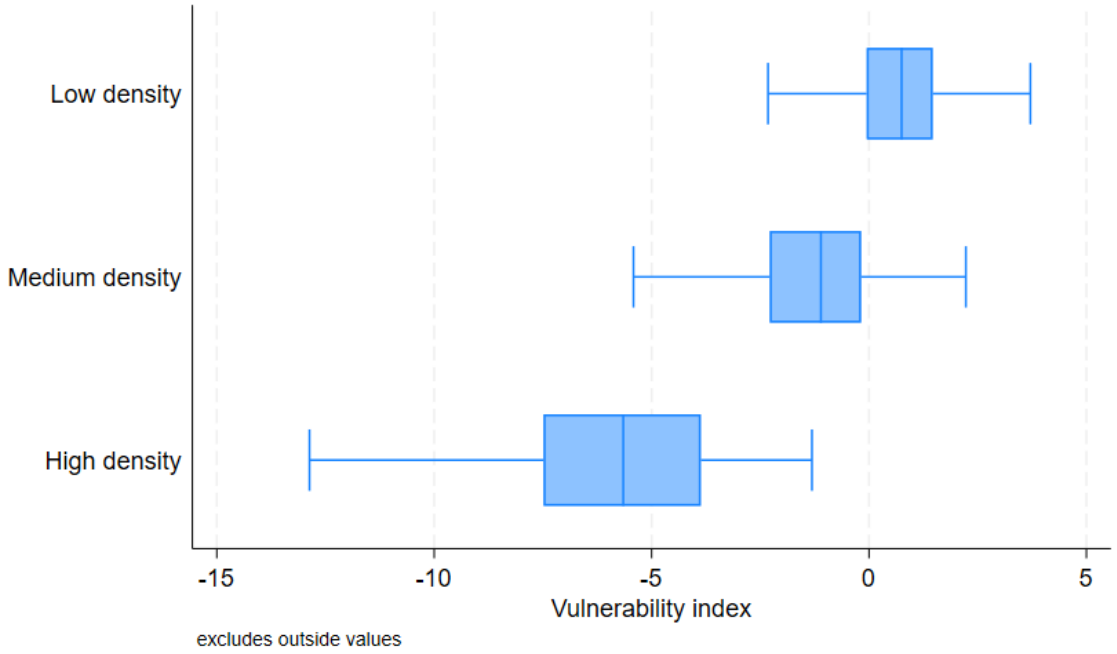
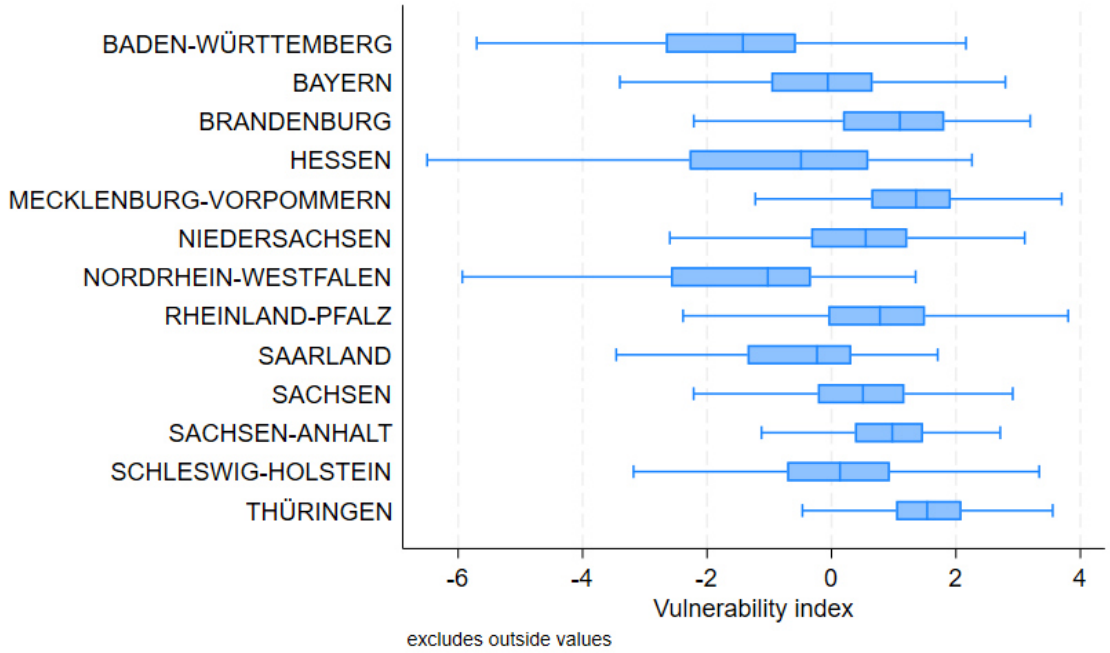
Analysis at state level



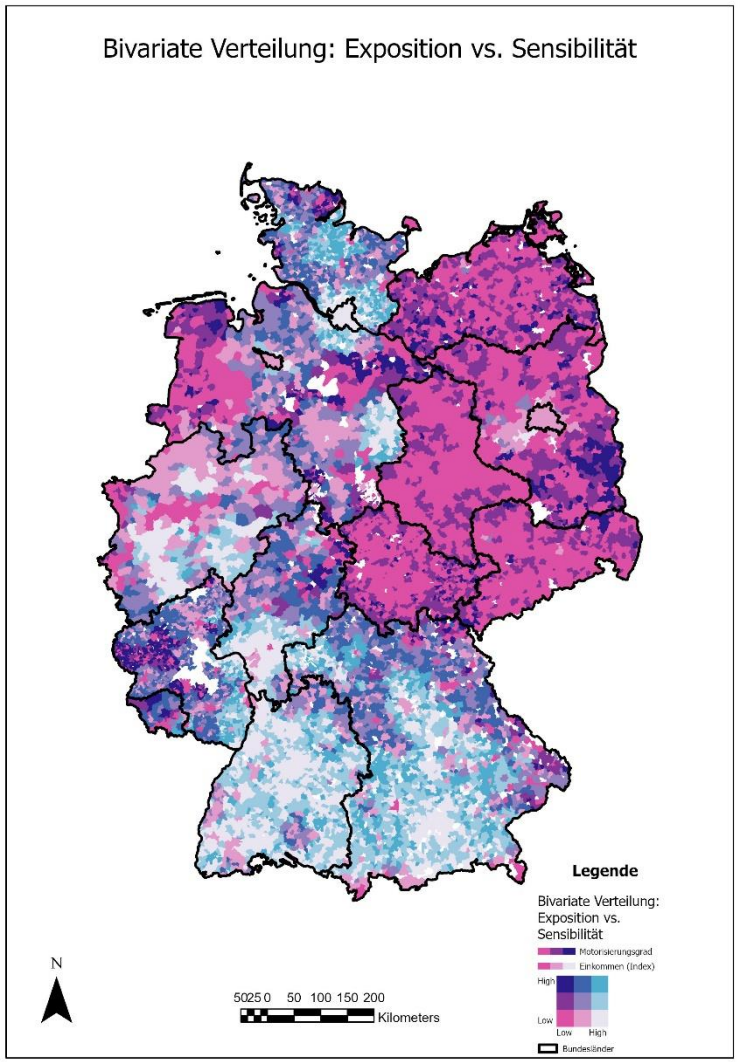
- ca. 1.9 million people / **2.3% of the population live in municipalities with the highest vulnerability** (top quintile)
- ca. 53 million people live in the municipalities with the lowest vulnerability (bottom quintile)

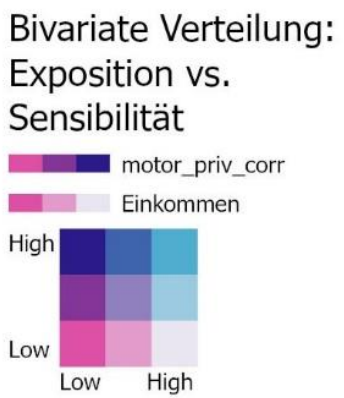
Findings: composite indicator





Findings: Exposure vs. Sensitivity





- **Dark purple** = areas with **high motorisation despite low income** (sometimes referred to as 'forced car ownership')
- Can result in trade-offs between expenditure required to run and maintain the vehicles and expenditure on other necessities
- **ca. 2.0 million people** live in the 1005 municipalities with high exposure and high sensitivity
- ca. 19.3 million people live in the 1524 municipalities with low exposure and low sensitivity (light grey)

Findings: Exposure vs. Adaptive Capacity

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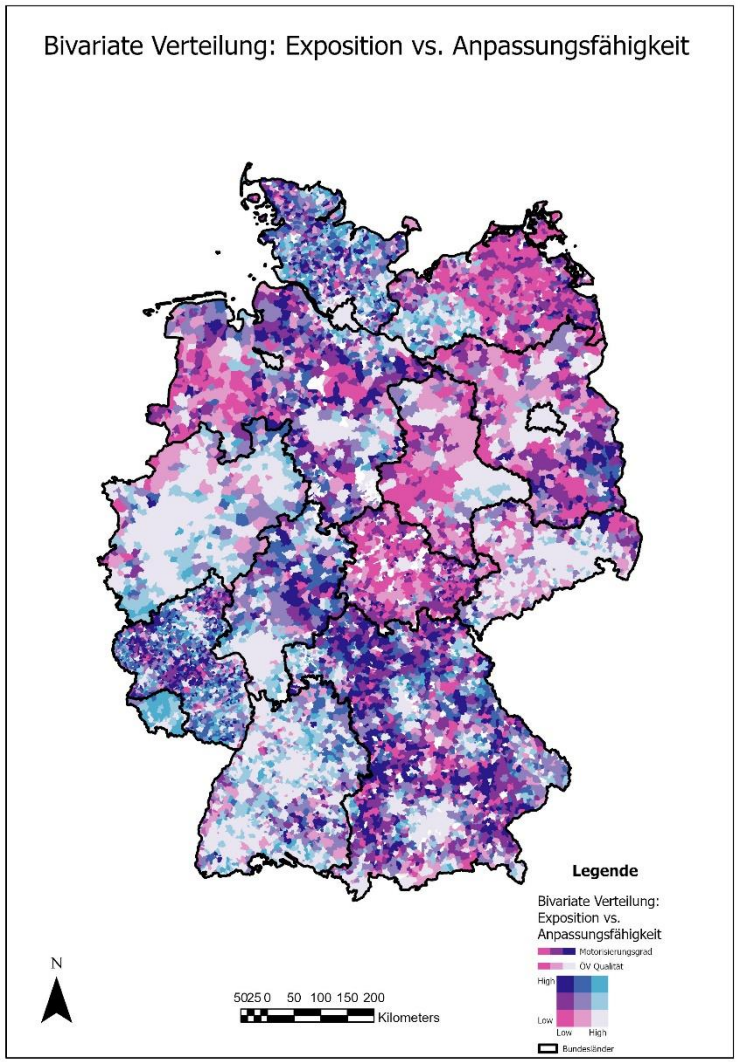

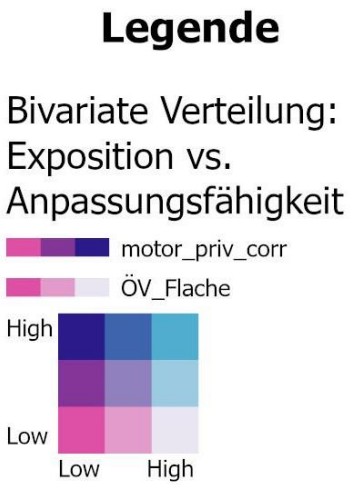

- **Dark purple** = areas with **high motorisation and poor public transport quality**
- **Car-dependent areas**: residents are more likely to rely on cars for their daily mobility needs
- **ca. 1.7 million people** live in the 1436 municipalities with high exposure and low adaptive capacity
- ca. 53.8 million people live in the 1672 municipalities with low exposure and high adaptive capacity (light grey)

Findings: Sensitivity vs. Adaptive Capacity

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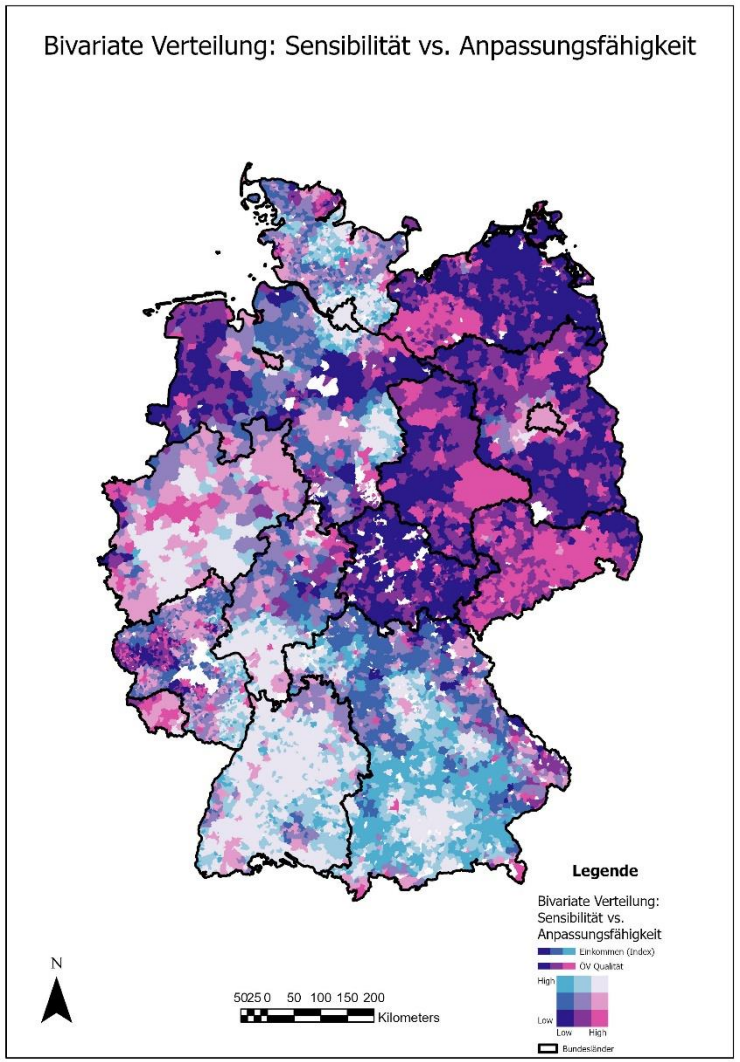

- **Dark purple** = areas with **low income and poor public transport quality**
- Could be considered as areas deserving more government investment in public transport
- **ca. 1.9 million people** live in the 736 municipalities with high sensitivity and low adaptive capacity
- ca. 14.5 million people live in the 762 municipalities with low sensitivity and high adaptive capacity (light grey)

Findings: international comparison

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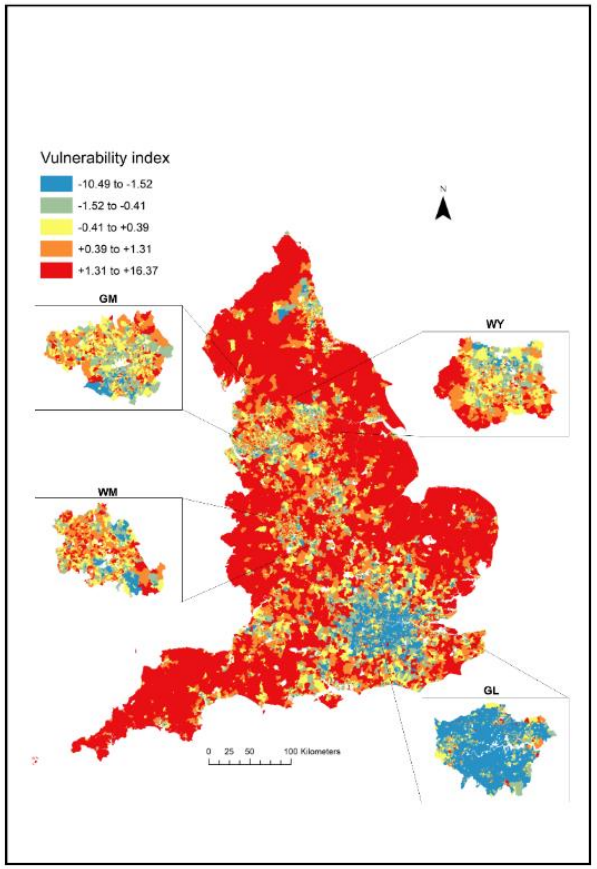
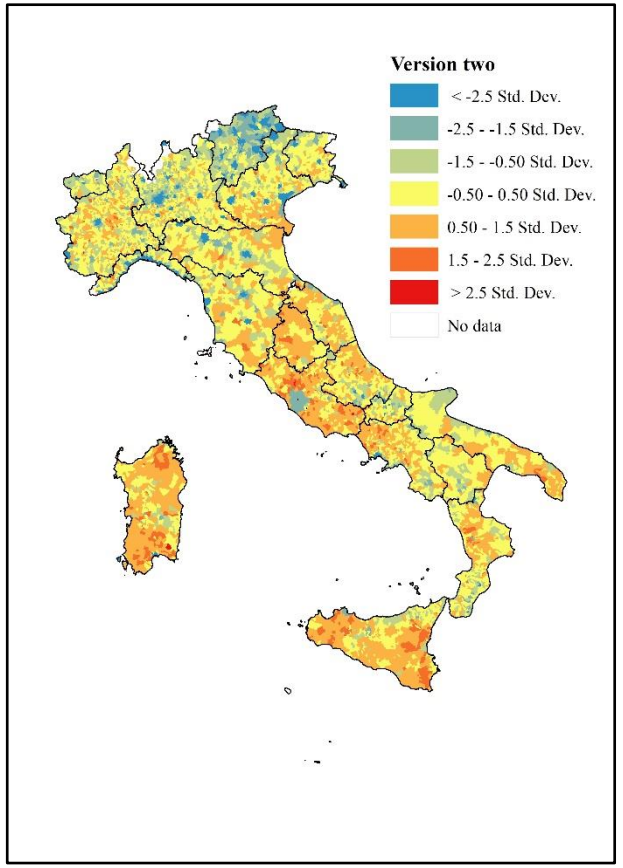
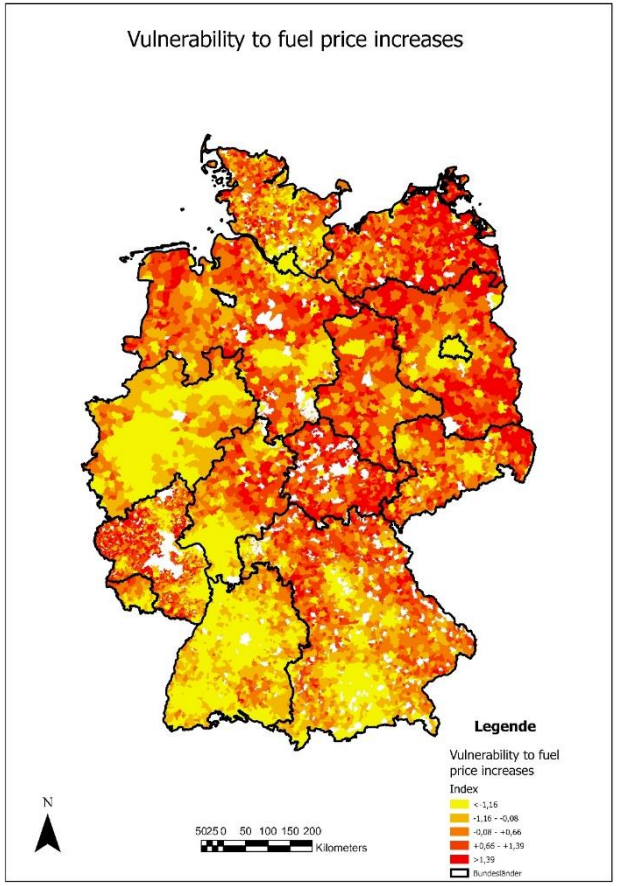


(Mattioli et al., 2019)



(Mattioli et al., 2023)



Conclusions

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SUBSTANTIVE

- A phenomenon with a **complex geography**: not something that affects each and everyone outside of large cities (as sometimes implied)
- Noticeable **differences between Bundesländer**:
  - ➢ demonstrate impact of federalism
  - ➢ vulnerability is partly the result of policy decisions (e.g., re: public transport provision)

METHODOLOGICAL

- Vulnerability to fuel price increases **can be mapped in Germany despite several data limitations**
- Possible further developments:
  - – Improve adaptive capacity indicator with better accessibility statistics (Thünen Atlas)
  - – overlap between vulnerability and EV adoption
  - – overlap between vulnerability and housing affordability

Thank you for your attention!


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