Mobility Gini: distributional effects of climate policies through transportation choices

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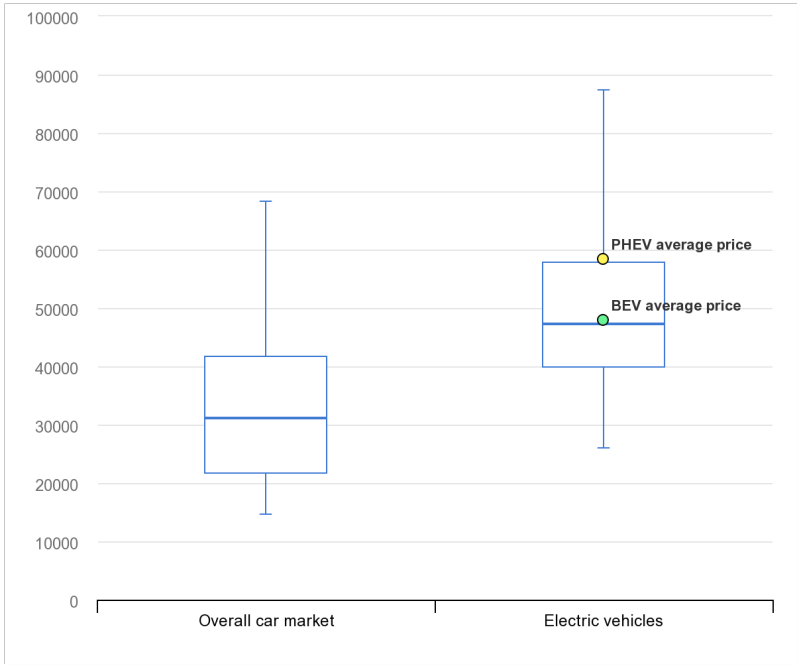
Low acceptability of policies for the transition

An example from France:
Increase of fuel taxes (2018) $\rightarrow$ The yellow vest movement
Followed by protest all around the country given the burden on middle and low income classes.

- Climate change policies are believed to increase inequality (Douenne and Fabre 2022)
- Have low acceptance (Dechezleprêtre et al. 2022)
- Create transition delay

Potential unequal effect of policies for the transition

The EU ban of diesel & emitting new car sales by 2035, massive introduction of EVs, while prices remain higher than counterparts.

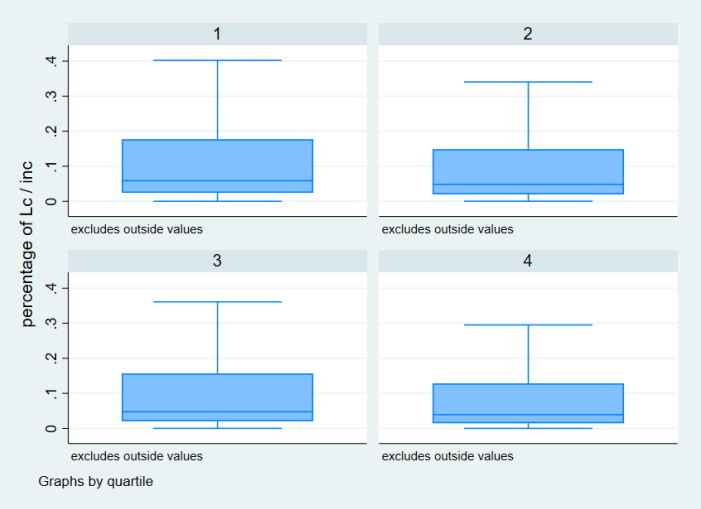


Note: Purchase price of electric cars vs. overall car market in EU, 2021-2022. Source: IAE - Global Electric Vehicle Outlook 2022

However, inequality in transport and income not 1:1

Inequality in transport not only due to income but due to multiple characteristics of households.

Heterogeneity in expenditure per quartile



Note: Boxplots represent the percentage of expenditure in transport $\frac{expense}{income}$*. All four income quartiles have similar transport expenditures, as given by the average, however, there is heterogeneity inside each quartile. Quartiles ranked in ascending order, from lowest to highest income.*

Summary of the paper

Research Question #1

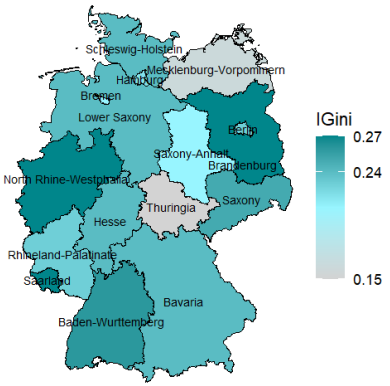
How do public policies for the transport transition impact household choices and transport inequality?

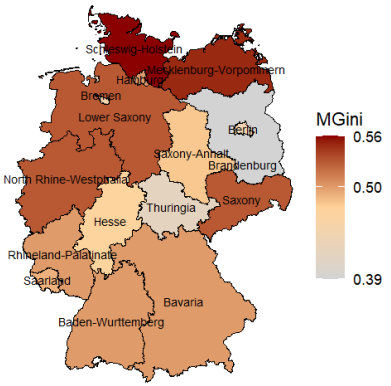
1. Microeconomic model of household choice of transport and consumption

Research Question #2

How to quantify heterogeneity in transport cost?

1. Mobility Gini based on the Electric Gini of Levinson and Silva (2022)





Outline

Part 3: Theoretical model of household choice

Theoretical framework: household model of transportation choice

$\forall i$ household, the utility writes:

$$U\left(l_G, x, \bar{T} - l_T, TD\right) \tag{1}$$

$$U = \left[\gamma \ln(l_G) + (1-\gamma)\ln(x)\right] - \frac{\delta}{2}\left(\bar{T} - l_T\right)^2 - \sum_j TD_j \tag{2}$$

$$w * t = x + \sum_j d_j * LCOKm_j \tag{3}$$

$$\frac{\partial U}{\partial l_G} > 0 \quad ; \quad \frac{\partial U}{\partial x} > 0 \quad ;$$
$$\frac{\partial U}{\partial nl_T} < 0 \quad ; \quad \frac{\partial U}{\partial TD} < 0$$

Notes: The household chooses how much d_j and x to consume subject to the budget constraint. And l_G is proxied by the share α_j of total d_j that is actually traveled for amenities

▸ FOCs ▸ Costs details ▸ X-D Arbitrage ▸ Alphas ▸ Full budget ▸ Solver

Related literature

Transport and Urban Economics
VOTT (value of *travel* time):

- **VOT**: opportunity cost of time (Becker 1965; Evans 1973; Small 2012)
- **and real (dis)comfort**(Kamplimath, Shivam, and Goenka 2021; Masoumi 2019; Sivilevivius et al. 2012)
  - Consumer physical & personal comfort
  - Convenience
  - Enjoyment
  - Usually homogeneous across households

Empirically[1]: WTP for travel time savings & Elasticities wrt. income, distance, time, costs (Hess et al. 2017; Batley et al. 2019)

Contribution: $\beta_j \rightarrow$ (Dis)comfort of 1h traveled by a household

Heterogeneous, depends on household socioeconomic characteristics and preferences, means of transportation j, distance traveled d_j

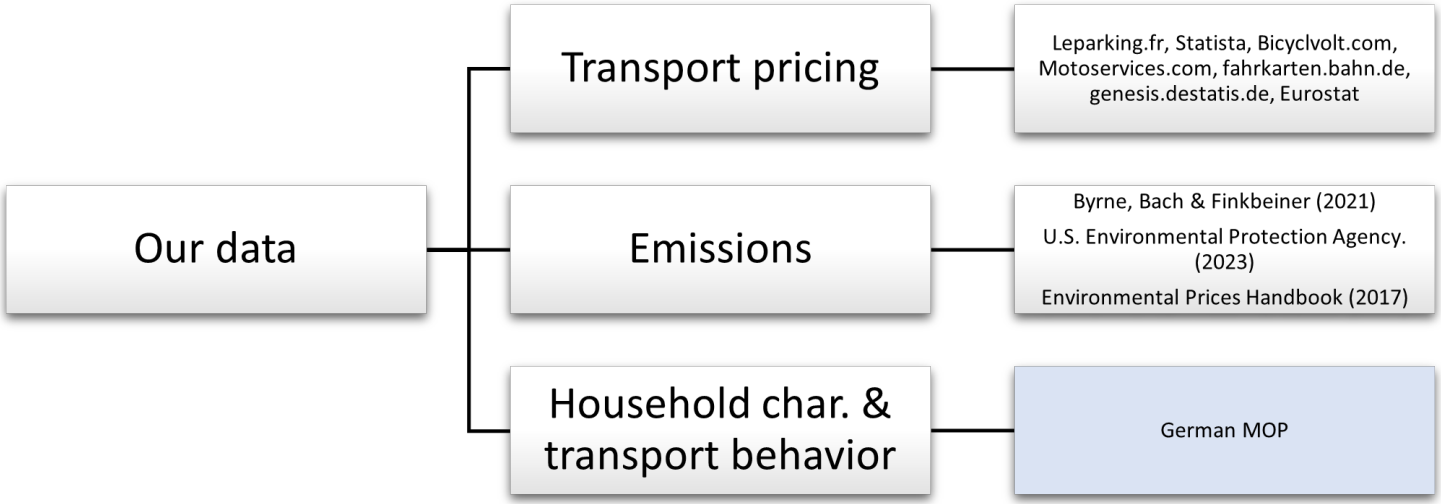
[1] SP experiments (Requires detailed experiments) or RP surveys (Differences stated vs. observed behavior), using Random Utility Models (RUM) and logit models to decompose heterogeneity

Part 2: The dataset

The dataset

1. Based on the German National Travel Survey (MOP)
2. Representative survey
3. Focus is on the household
4. 11k+ households (employed adults with and without children)
5. Period of 2004-2018
6. Enriched with multiple sources for transportation pricing & emissions
7. We focus on six main transport methods: foot, bike, car, moto, public transport (inside the city) and train.

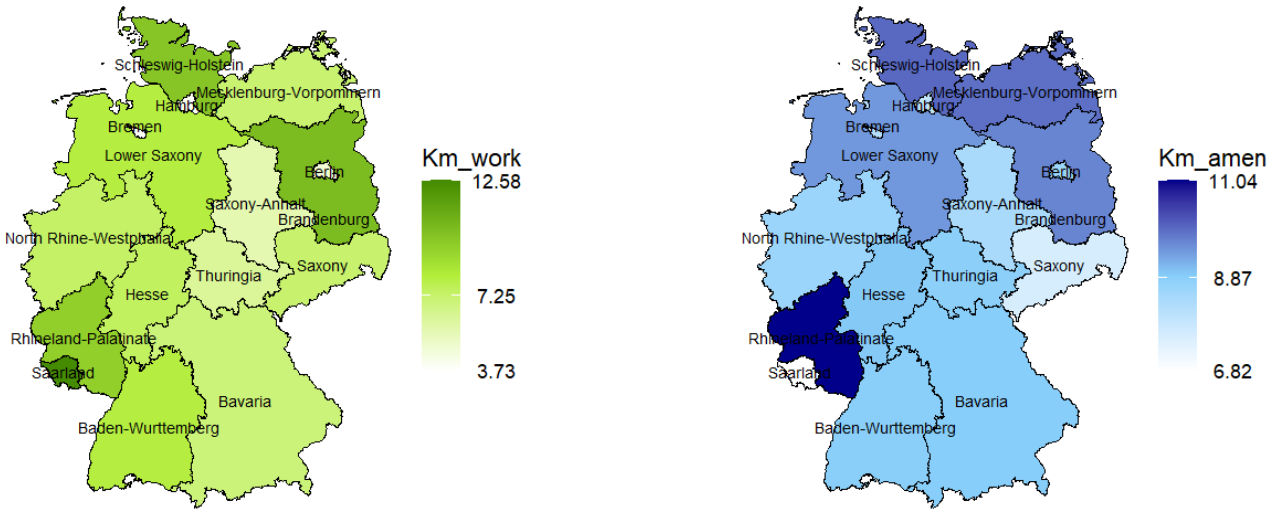
Dataset - all (summary)



Focus on household behavior
& six modes of transport (foot, bike, moto, car, inner-city public transport & inter-city public transport).

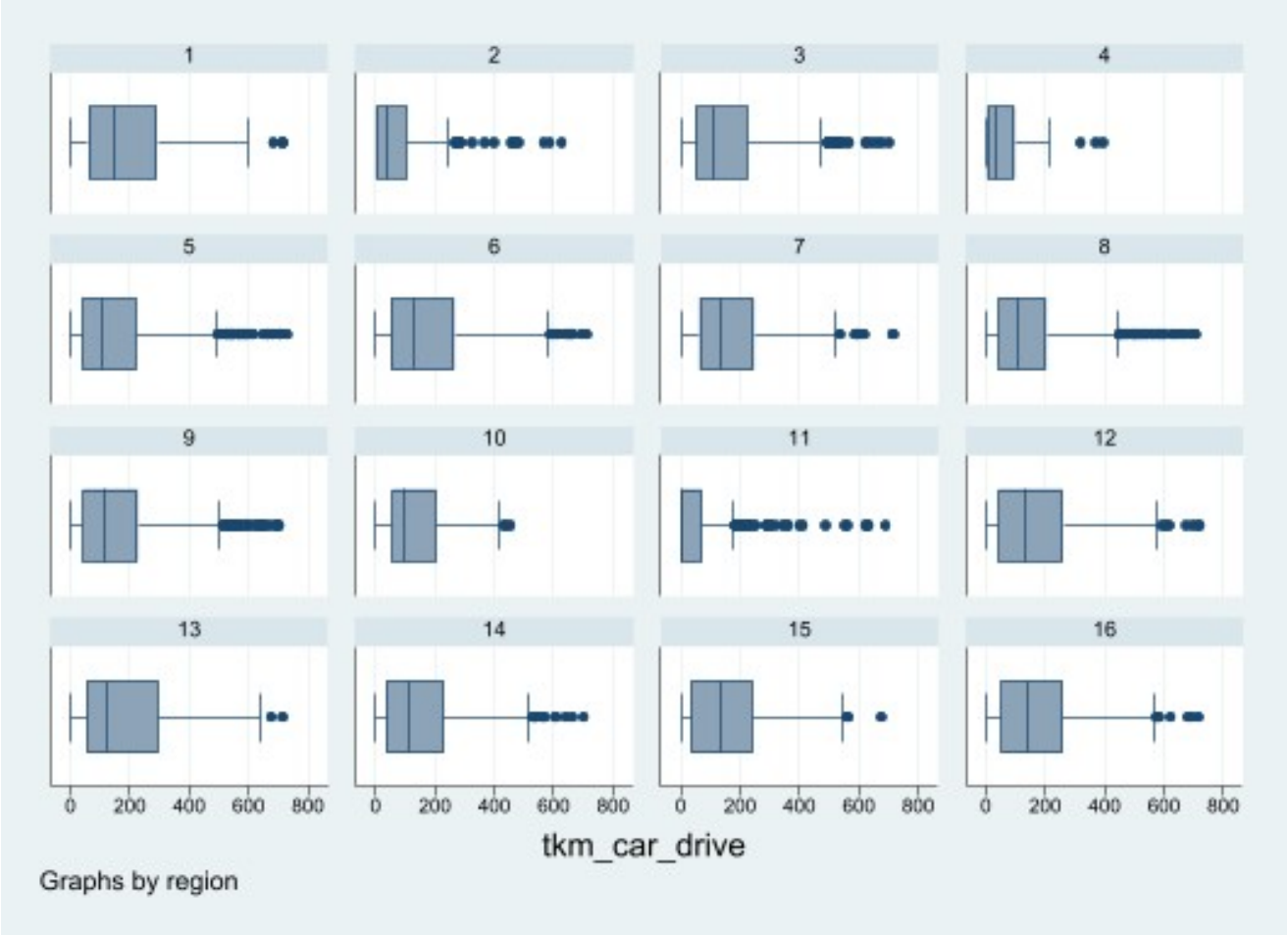
High heterogeneity between regions (by purpose)

Daily distances for work and amenities



Notes: The daily distances shown are the average at household level per region. Amenities include going shopping, running errands, leisure, dropping of or picking someone up. It excludes going to work and work-related trips.

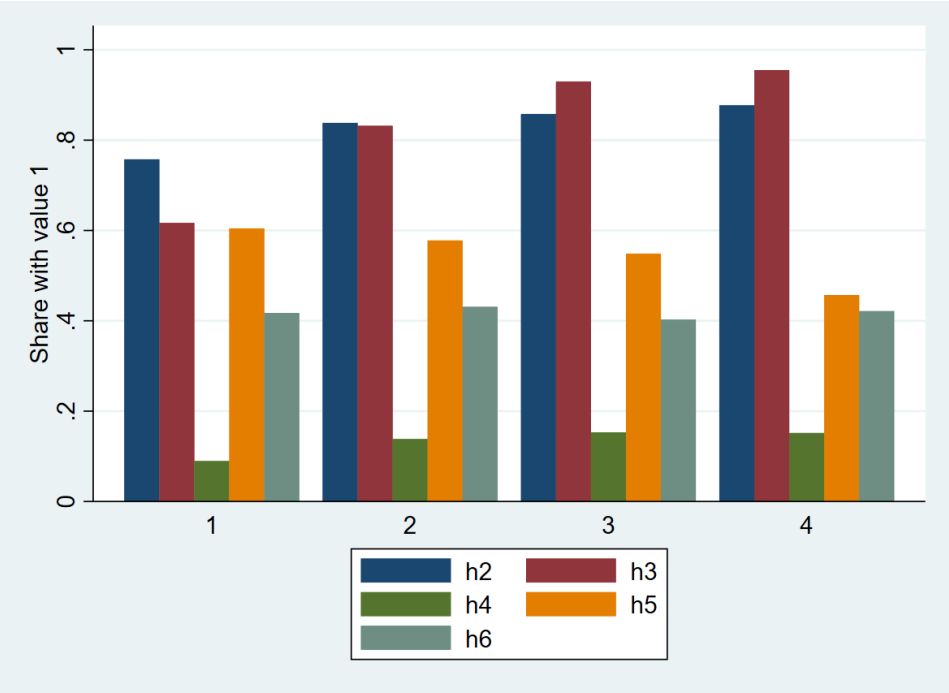
High heterogeneity between regions (by transport mode)



Note: boxplots illustrates the differences in distance traveled by car for each region.

Trends in access to methods of transport

The number of bike and car owners (H2-H3) increases with income while the number of public transport ticket holders (H5-H6) decreases with income.



Note: H2 - bike, H3 - car, H4 - moto, H5 - PT pass (inside city) & H6 - Bahncard. Graph is presented by income quartile.

Part 4.1: Empirical Applications - Calibration

A representative German household

▸ Policy shocks

Homogeneous parameters:

- δ : willingness to spent time working and travelling $\rightarrow$ 0.0005
- γ : preference for travel vs. for consumption $\rightarrow$ 0.353 (! heter. : 0.355 (0.496))

Heterogeneous parameters:

- w : wage per hour $\rightarrow$ 42.82 (97.08)
- t : hours worked per week $\rightarrow$ 39.89 (22.88)

Par.	Foot	Bike	Car	Moto	PT	Train
d_j	1.92	5.78	84.95	10.29	14.51	11.95
β_j	0.032	0.038	0.012	-0.078	-0.031	-0.074

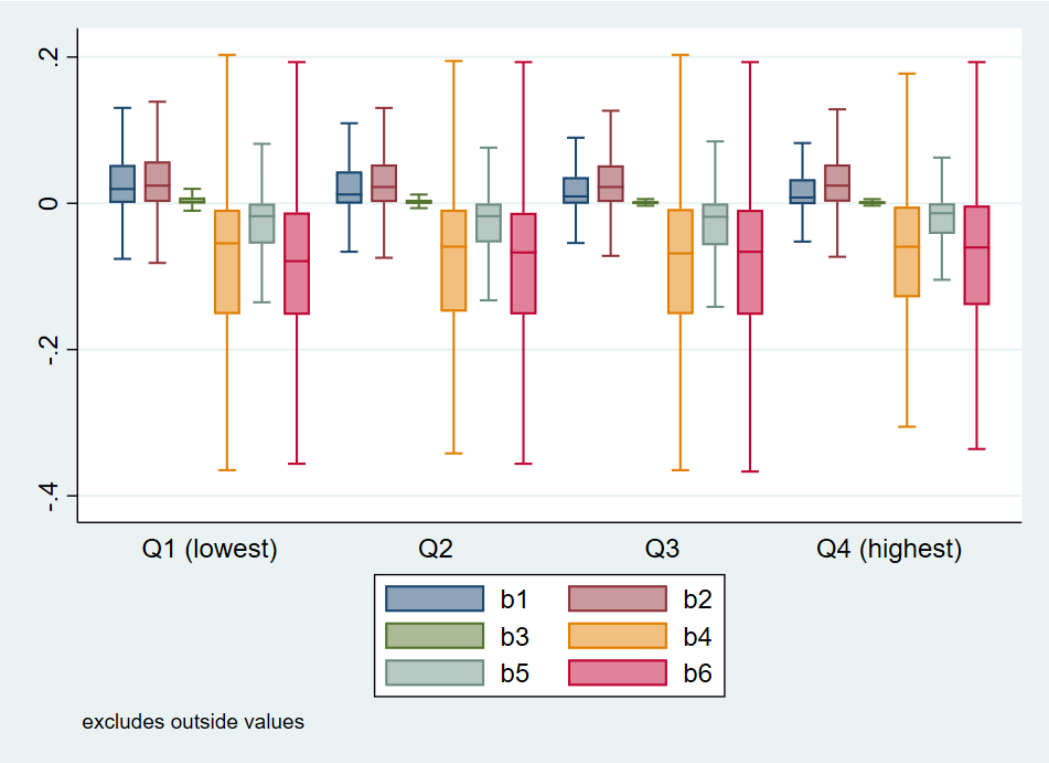
Notes: Values presented are the average for each variable over the sample period for all households. Calibrated parameters from the sample: δ, γ, β_j. Other variables are directly observed. γ and δ are homogeneous among households and calculated from the sample. The higher the β the larger the discomfort.

▸ Heterog. β ▸ Alphas

Heterogeneous β_j ▸ Preferences

No evidence of large variation between income groups. However, there is variation in Travel Discomfort for each method of transport.

Distribution of heterogeneous β_j by income quartile

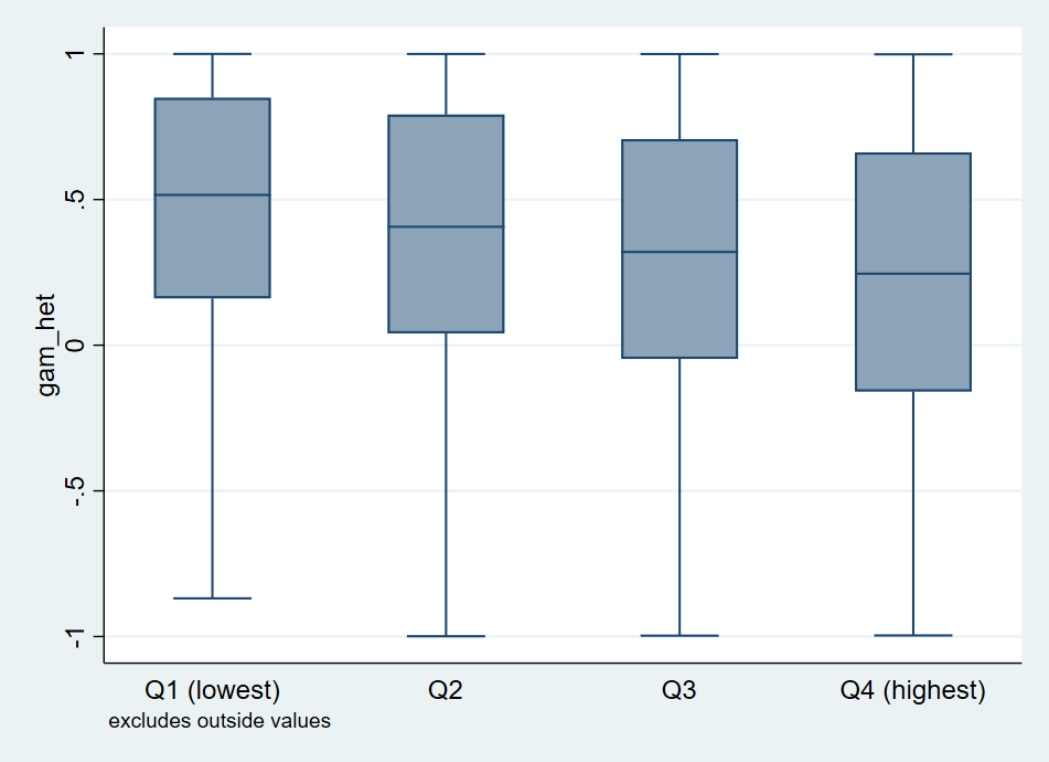


Note: β_1 = *foot;* β_2 = *bike;* β_3 = *car;* β_4 = *moto;* β_5 = *PT (innercity);* β_6 = *train.*

Heterogeneous γ

γ : trade-off / willingness to spend between l_G vs. x.

Distribution of heterogeneous γ

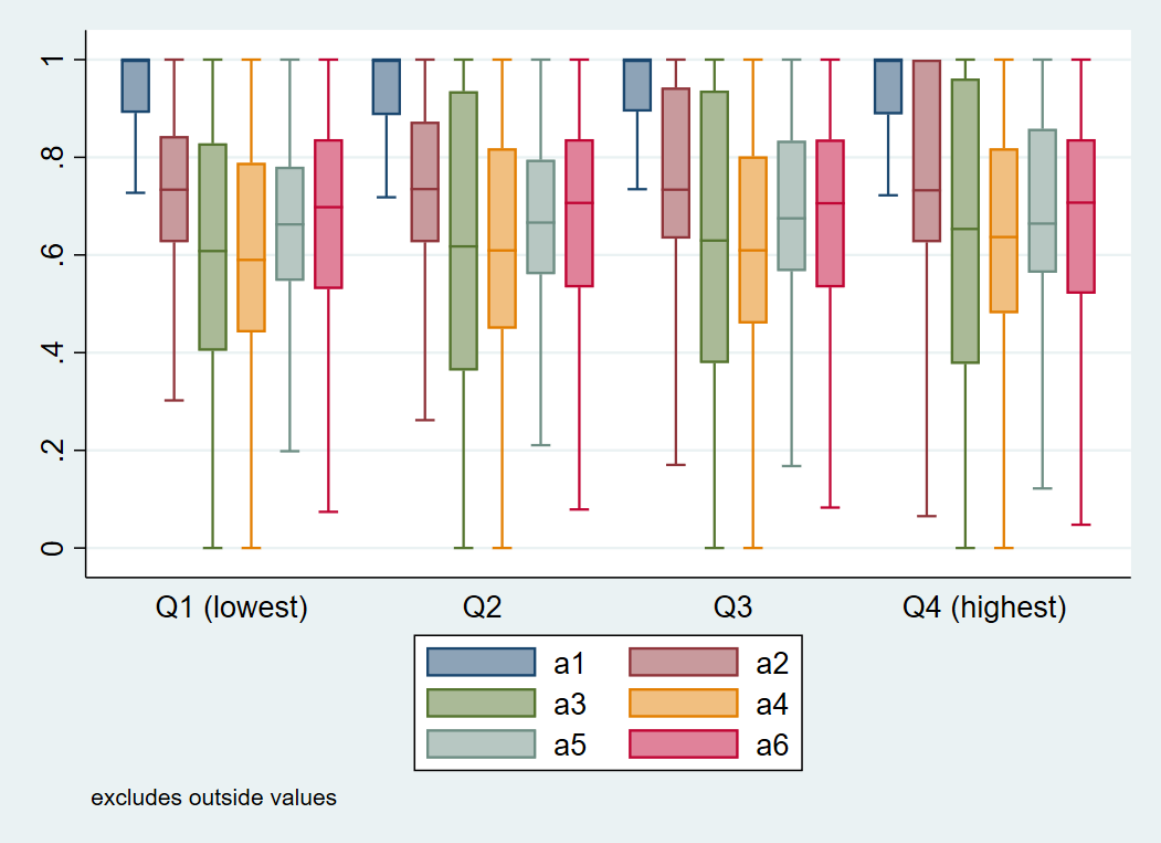


Note: The richest populations can (on average) allocate the largest shares to consumption of other goods while the poorest allocate more to l_G

Transportation variables

Back

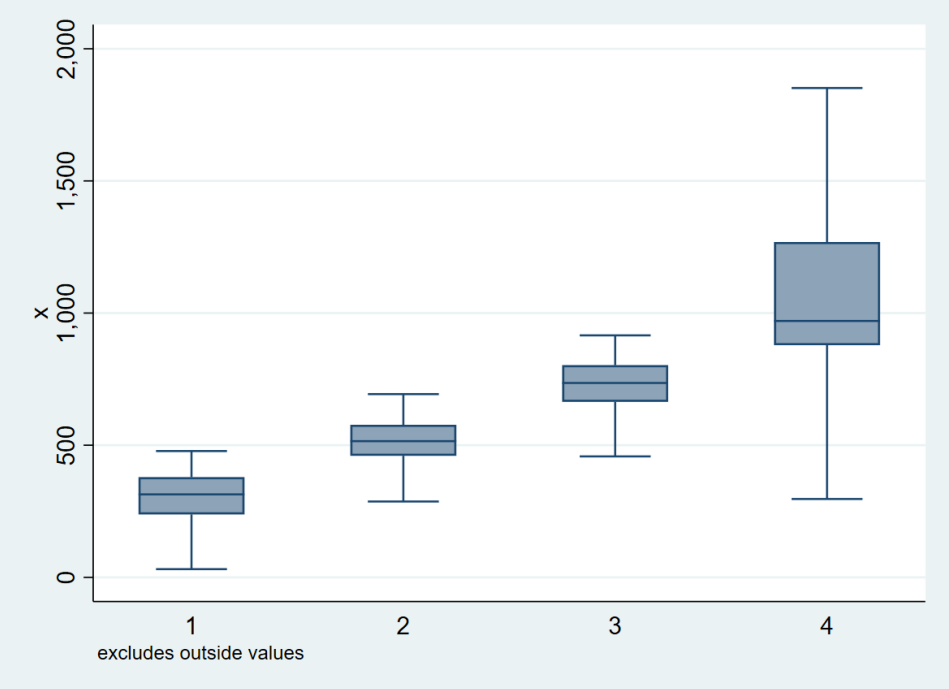
Shares of the distance traveled for amenities by income quartile



Note: Stark differences Q1 vs. other for car (A3) & bike (A2). The poorest use the car the least for amenities, the richest use the bike the most for amenities. Other methods remain stable

X: budget left for other goods

Or *Income After Transport Expenditure*

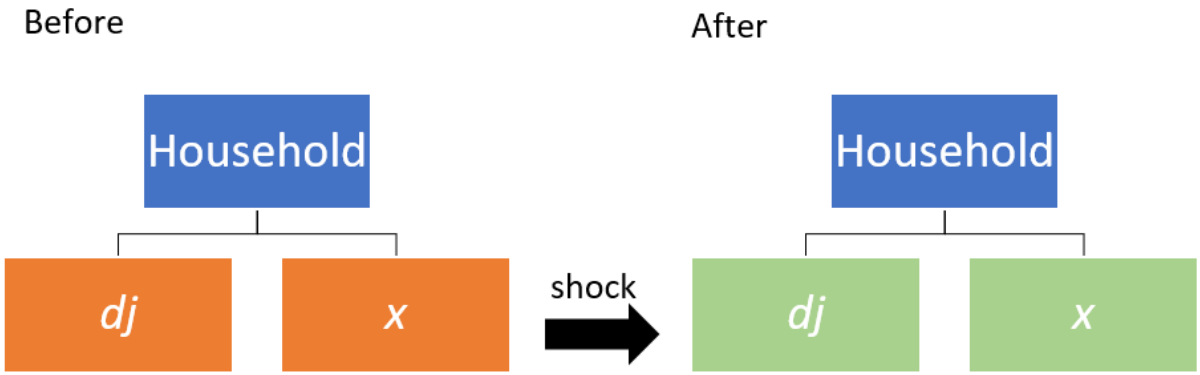


X: budget left for other goods presented by income quartile

Part 4.2: Empirical Applications - Policy shocks to *LCOKm*

Policy shocks to $LCOKm_j$

How does the household adjust its travel & consumption choices when a policy alters the $LCOKm_j$:



Household allocation of x and d_j following policy shocks

Rep.hh

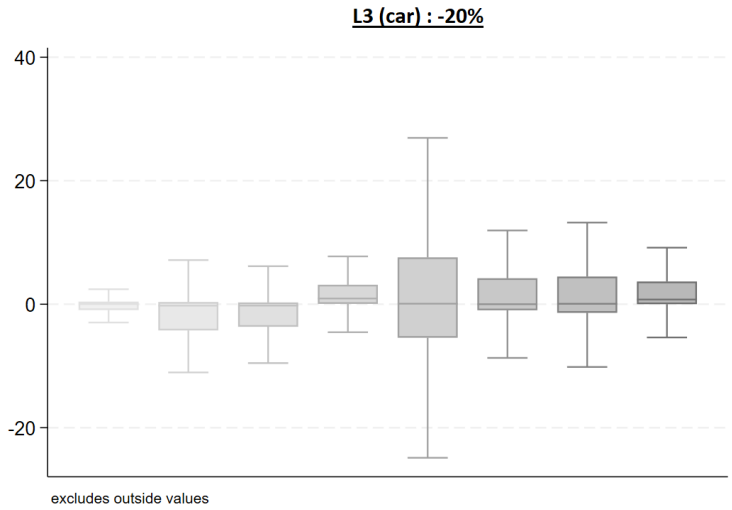
Short-term changes in behavior and inequality due to policy shocks ($LCOKm_j$)

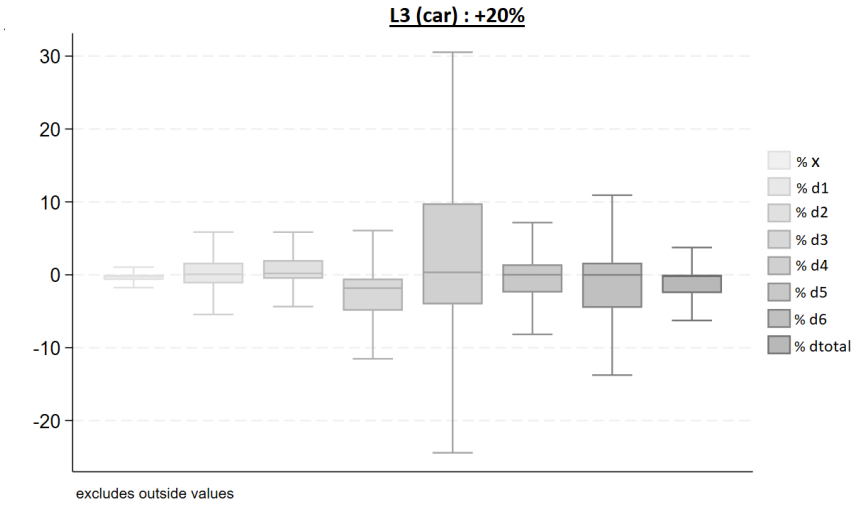
Policy	x (%Δ)	d_{foot} (%Δ)	d_{bike} (%Δ)	d_{car} (%Δ)	d_{moto} (%Δ)	d_{pt} (%Δ)	d_{train} (%Δ)	MGini (%Δ)	EMGini (%Δ)	Example
L_{Car} +20%	4.52	-1.07	4.30	-3.11	19.93	1.48	-1.27	3.7	2.6	2035 ICEV ban
L_{Car} -20%	4.10	-3.57	-0.33	2.22	12.75	3.70	3.72	-1.7	-1.2	subsidies
L_{Bike} -15%	4.26	-2.27	1.45	-0.85	14.56	2.37	2.49	-2.6	-1.8	subsidies

Notes: Columns present percentage changes in other goods consumed X, distances traveled for each method of transport and Gini Indexes following selected policies.

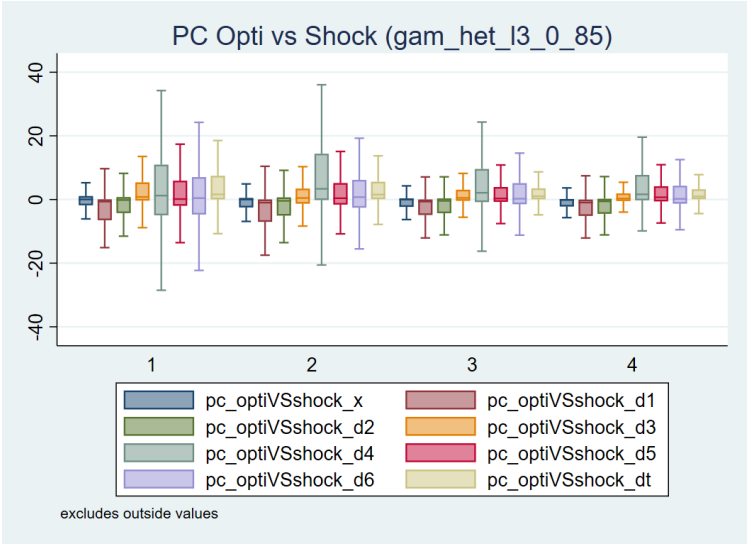
Difference between MGini & EMGini is cost of pollutants → key implications for policy makers.

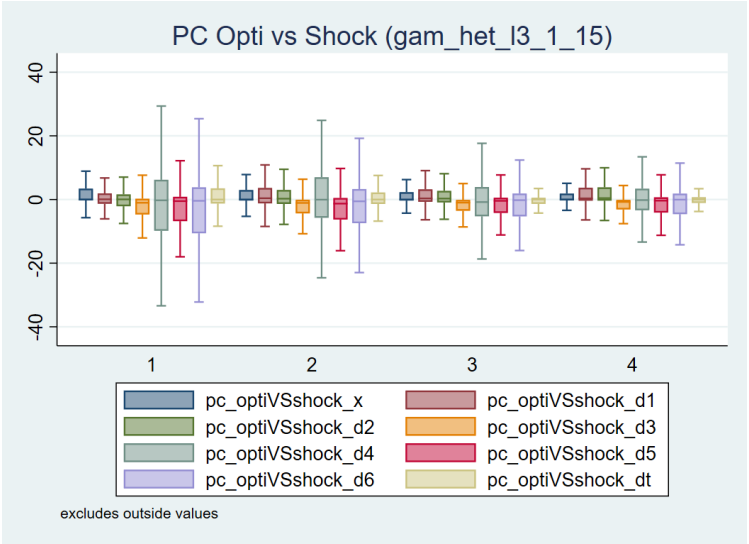
Household allocation: visual results





Household allocation differs across income groups





- Larger variation in distances traveled by lower income quartiles
- A decrease (increase) in L3 leads to an increase (decrease) in use of J3 (car)
- Car is a substitute for foot & bike but a complement with public transport & moto.

Part 4.3: Empirical Applications - The Mobility Gini

Modeling three Gini Indexes

1. Mobility Gini (MGINI) = distance and ride costs

$$COST = \sum_j d_j * r_j = \sum_j d_j * \left(L_j + \frac{w}{s_j} \right) \tag{4}$$

2. Emissions Mobility Gini (EMGINI) = MGini and emissions costs

$$TOTAL\_COST = \sum_j d_j * \left(\sum_k e_{kj} * p_{ek} + r_j \right) \tag{5}$$

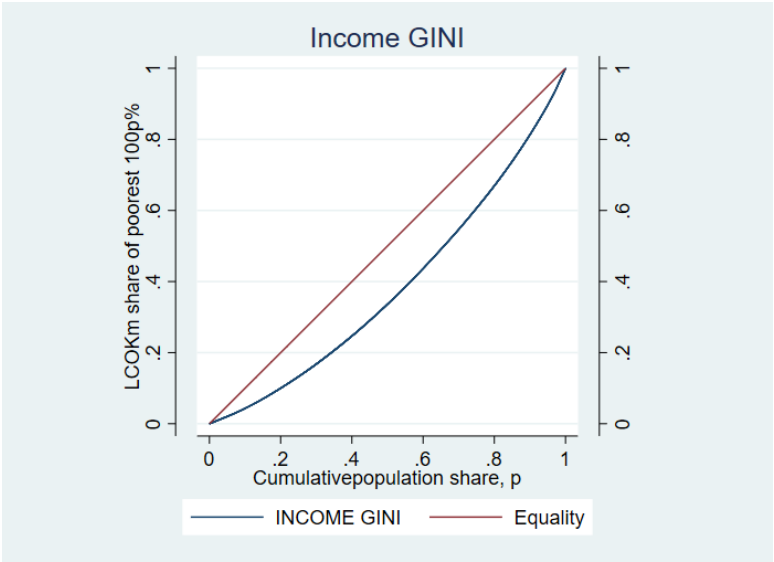
3. Income Gini (IGINI) = income

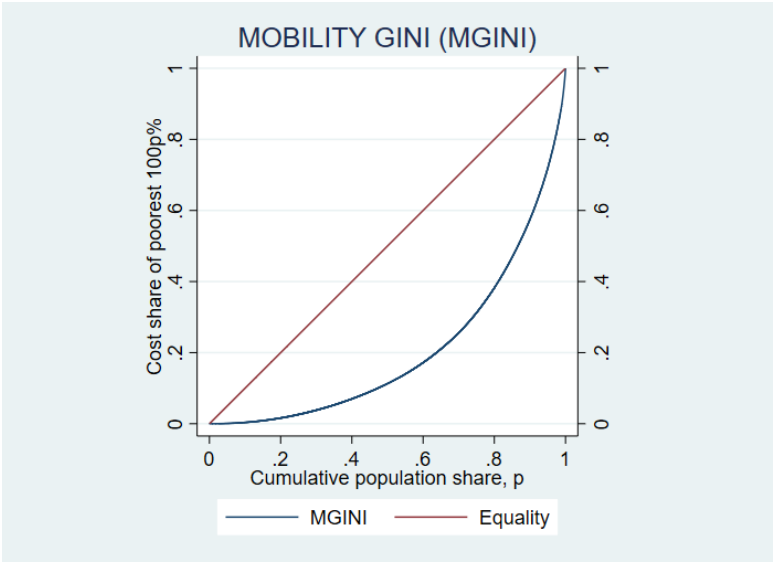
$$INCOME = w_i \tag{6}$$

Modeling Gini & Lorenz Curves

▸ PanelMGINI ▸ Sum. Stats Gini ▸ Causality

Lorenz Curves IGINI and MGINI



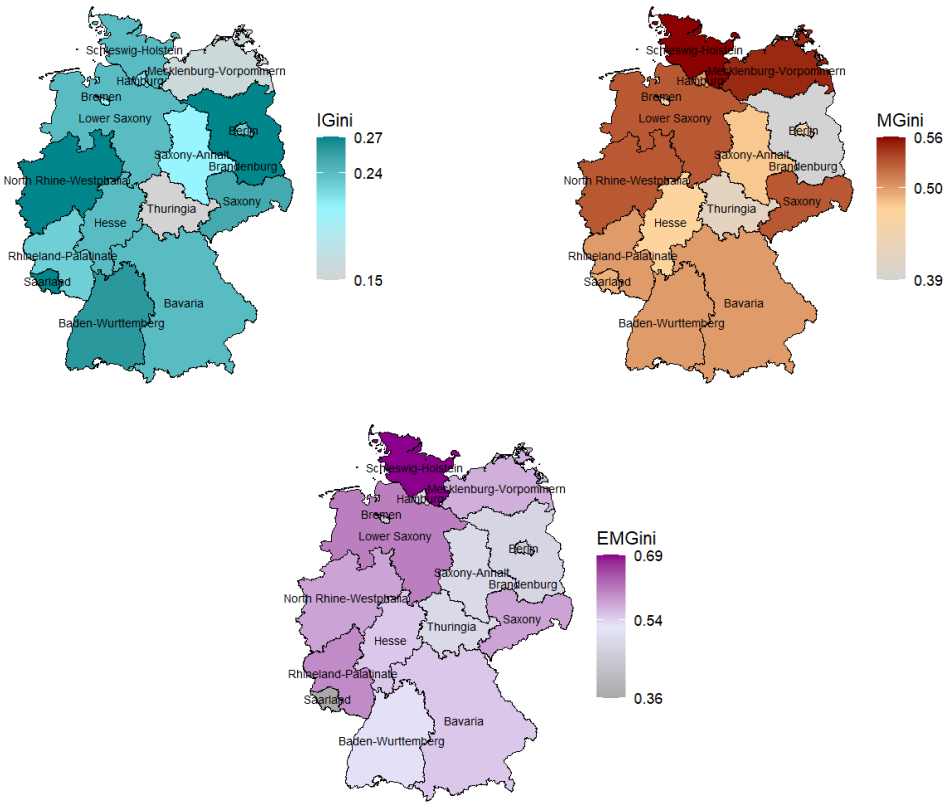


The Gini is calculated as the area between the 45 degree line and the curve. The higher the area, the higher the level of inequality. MGini $\tilde{3}x$ higher than IGINI

Regional heterogeneity

▸ TableMGINI ▸ Temp. Evol. ▸ Temp. dif. Gini

Regional heterogeneity between Gini indexes (2018)

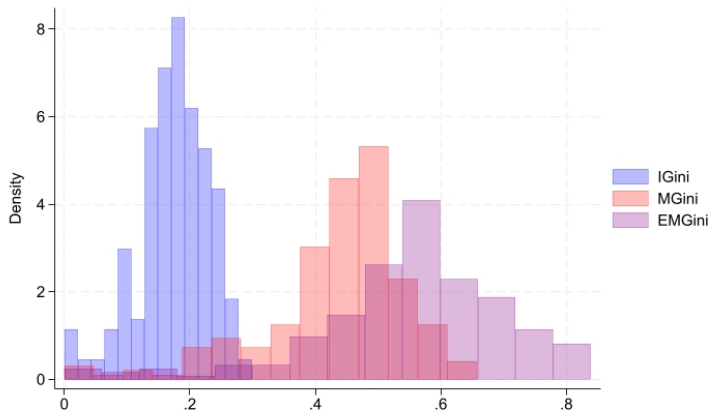


Note: Scales differ by index: numbers in scale represent min., avg., and max. for each index. Higher index represents higher inequality, where 1 would represent perfect inequality and 0 would represent perfect equality.

Policy implication: correlated but not causal

Correlation does not mean causality:
Dumitrescu & Hurlin (2012) Granger non-causality tests show no causality between Mobility GINIs and Income GINIs. → Key implication

Comparison distribution of selected Gini indexes.



Correlation of Gini Indexes

Dependant Variable:	MGini	EMGini
Income Gini (IGini)	0.575***	-.053
Year FE	Y	Y
Region FE	Y	Y
N	256	256
R^2	0.15	0.14

*Note: VCE robust standard errors. The significance levels are indicated such as * $p < 0.10$, ** $p < 0.05$,*** $p < 0.01$. SGini is calculated with middle prices for the pollutants.*

Part 5: Conclusions

Contribution and Conclusion

1. Theoretical model to estimate impact of transport policy on household decisions & inequality
2. Quantification of heterogeneous travel discomfort β_j
3. Decomposition of distributional effects of policies for the transition of the transport sector
4. Creation of inequality measures in transport cost (Mobility Gini Indexes)
5. Implications for Germany: Mobility Gini different from Income Gini, erroneous policy targeting
6. Future work could expand to other countries with National Travel Surveys (all EU)
7. Future work could focus on estimating willingness to change modes via nudges

THANK YOU

Comments? Questions?

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