Impacts of four road pricing scenarios on individual welfare
- the case of the German motorways -

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Agenda

- Motivation
- Methodology
    - Calculation of Welfare Changes
    - The Road Pricing Scenarios
- Data Source
- Results
    - Characteristics of the households
    - Impacts of the scenarios
- Conclusions and further research

Motivation

- **Deep disagreement** in previous literature on the effects of road pricing schemes

- Recent discussion in Germany (e.g. BMVBS; ADAC, CDU/CSU)

- Is road pricing an alternative way of **funding transport infrastructure** in times of strained public household situations (incl. debt crisis of OECD countries) – "Affektionsprinzip"?

- **Does a trade-off** between improved infrastructure, reduced travel times, cost-by-cause principle and social exclusion, overtrading of people, freedom of mobility **exist**?

- Do **compensation measures** exist which reduce negative effects of a road pricing implementation?

Motivation – problem with the HH's financial basis

- **Income distribution** in Germany as applied in most road pricing studies (Basis: total HH income)
- Classification leads to wrong conclusions (see number of persons per HH)

EK-Klasse*	Anzahl HH [%]	Durchschn. Netto-HH-Einkommen [Euro/Monat]	Mittlere Anzahl Personen im HH	Mittlere Anzahl Pkw im HH	Gesamt-fahrleistung nicht dienstlich* [km/Jahr]
1	34,2	1413	1,74	1,13	9103
2	18,8	2250	2,35	1,32	10406
3	14,4	2750	2,56	1,44	14204
4	13,7	3250	2,85	1,55	13155
5	18,8	4250	2,95	1,72	17287

* Einteilung gemäß Haushaltsnettoeinkommen
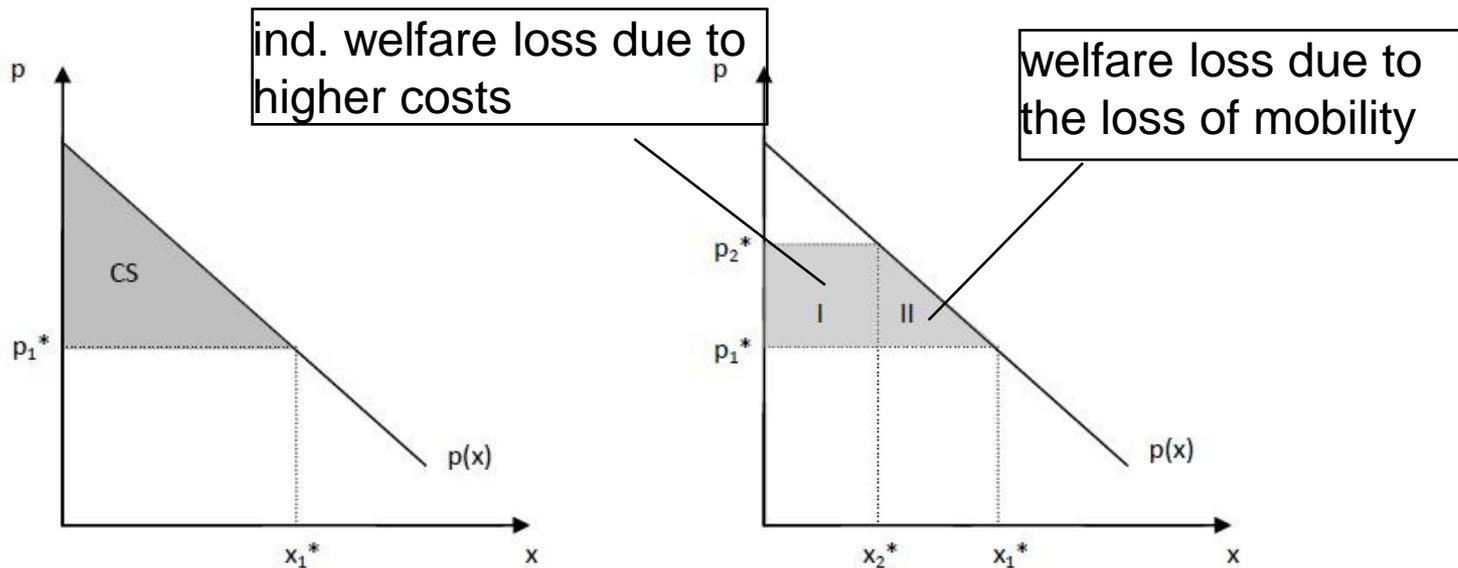
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Methodology - Calculation of Welfare Changes

- **Standardization of individual welfare**

- **Marshallian concept of consumer surplus**
  - **CS = area under the demand curve and above the market price p1***
  - **CS = Δ (area I + area II)**

ind. welfare loss due to higher costs

welfare loss due to the loss of mobility

Methodology - Calculation of Welfare Changes

Welfare changes are calculated in relation to the **household income** which is represented by the „**Equivalized Disposable Income**" (EDI)

EDI = total net income of a household / equivalent weight of HH-members

the equivalent weight is based on the modified OECD equivalent scale:
- **first adult: weight of 1**
- **subsequent member >= 10 years: weight 0.5**
- **members < 10 years: weight 0.25**

=> Consideration of **economies of scale**

=> Accurate comparison of HHs of **different sizes** and **compositions**

Methodology - The 4 Road Pricing Scenarios

time-based Scenarios	**distance-based Scenarios**

Vignette
- for one year (€ 140)
- foreign users (also for 10 days)

All users: € 0.04 per km
(based on Progtrans/IWW, 2007)

Scenario A	**Scenario B**	**Scenario C**	**Scenario D**
without compensation	with compensation	without compensation	with compensation

Methodology - The compensation opportunities

Compensation measures

Reduction of the energy tax

Reduction of the motor vehicle tax

Reduction of the energy tax

- The German fuel tax rate is very high compared to those of neighboring countries.
- Reduction of the **energy tax** by **0.05 € per liter fuel**

=> alignment of the German tax rate
=> reduction in "**gas tank tourism"**

Reduction of the motor vehicle tax

- The **motor vehicle tax** includes an **engine-based component (cylinder capacity)** and an **emission-based component (consumption per distance)**.
- Observable trend towards cars with smaller cylinder capacity
$\Rightarrow$**abolition of the engine-based component**.

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Data Source
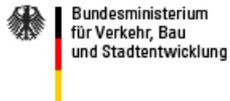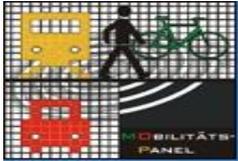
German Mobility Panel (MOP), 1994 - 2008

- Survey about the **everyday mobility behavior** of the German population, e.g. travel mode use, length of trips, vehicle-specific data

- Information of general characteristics of German households e.g. household income/size/type, car availability

- **Database**: 2008 panel

- **Data size**: 584 households, 1374 persons which represent 20,5 Mio. German households (50 % of total)

    - households without driving performance as well as erroneous information are excluded from the analysis

Data Source - Classification of income groups

- Classification is based on a **quintile household distribution** (according to a report by the Federal Statistical Office)

- HHs are classified according to their **households' EDI** into:
    - **Group 1: < 1.125 EUR/AEQ*month**
    - **Group 2: 1.125 - 1.375 EUR/AEQ*month**
    - **Group 3: 1.376 - 1.700 EUR/AEQ*month**
    - **Group 4: 1.701 - 2.167 EUR/AEQ*month**
    - **Group 5: > 2.167 EUR/AEQ*month**

- *AEQ = adult equivalent

Percentage of daily mileage on motorways

- Assumption:
  - Road pricing is implemented on **motorways only**
  - **Daily mileage** of every HH's motorway trips needs to be determined
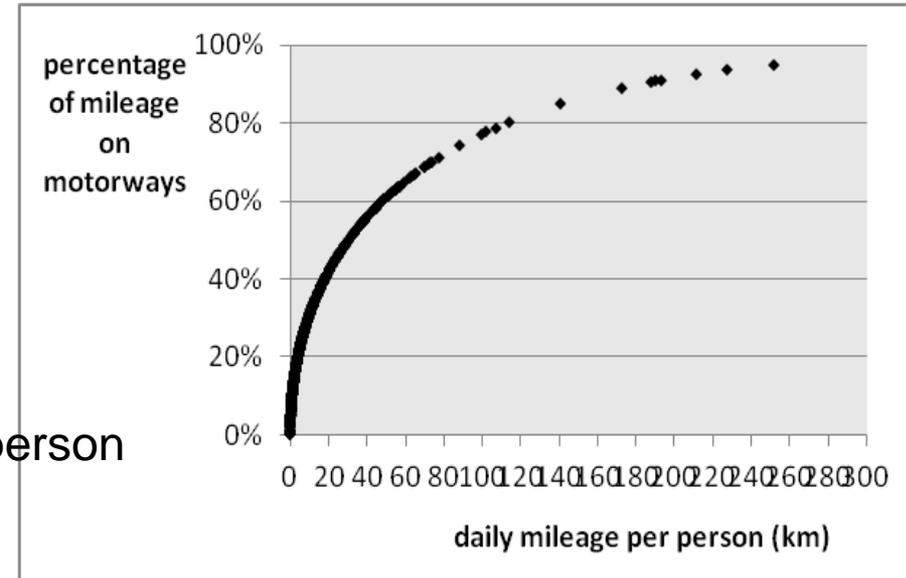 - Analytical function follows an **exponential function**

- **Calibration of parameters** is based on data of mileage of the panel´s households and data on the total mileages on motorways in Germany for the year 2008 (Verkehr in Zahlen 2009/2010)

$$A(x) = 1 - e^{-0,01144 \cdot x}$$

With:

x = total daily mileage of a person

A(x) = percentage of daily mileage of this person

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Characteristics of the households - structure

Einkommens-klasse*	Anzahl HH [%]	Durchschn. Nettoäquivalenz-einkommen [Euro/Monat]	Mittlere Anzahl Personen im HH	Mittlere Anzahl Erwachsene im HH	Mittlere Anzahl Kinder im HH	Mittlere Anzahl Pkw im HH	Mittlere Anzahl Pkw pro Erwachsenem
1	20,2	847	2,9	2,2	0,7	1,3	0,66
2	19,3	1222	1,9	1,6	0,3	1,2	0,82
3	21,7	1527	2,9	2,4	0,5	1,5	0,67
4	23,6	1959	2,3	1,8	0,5	1,3	0,80
5	15,1	2787	1,6	1,6	0	1,3	0,93

- Average **EDI** increases significantly between the income groups
- Average **number of adults per HH** decreases with increasing HH income (single HH in highest income group)
- Number of children decreases, too!
- Average **number of cars per HH** nearly constant.
- Average **number of cars per adult** higher for richer households

Characteristics of the households - Mileage

| Einkommens-klasse*	Gesamtfahrleistung nicht dienstlich pro Erwachsenem [km/Jahr]	Gesamtfahrleistung nicht dienstlich pro Pkw [km/Jahr]	Fahrleistung Autobahnen pro Erwachsenem [km/Jahr]	Fahrleistung Autobahnen pro Pkw [km/Jahr]
1	5277	8378	1294	2880
2	6069	8715	1732	2926
3	6108	9298	1778	3492
4	7556	9811	2611	3966
5	9593	10544	3707	4159

Tabelle 6.3: Durchschnittliches Verkehrsverhalten

Quelle: MOP 1994-2008, eigene Berechnungen

*Einteilung gemäß Nettoäquivalenzeinkommen

- **Mileage per adult** increases steadily with increasing income level (+81% from group 1 to group 5)
- **Mileage per car** increases, however, at much lower rates (++26% from group 1 to group 5)
- Mileage on motorways increases much more than mileage on secondary roads.

Characteristics of the households - Car availability
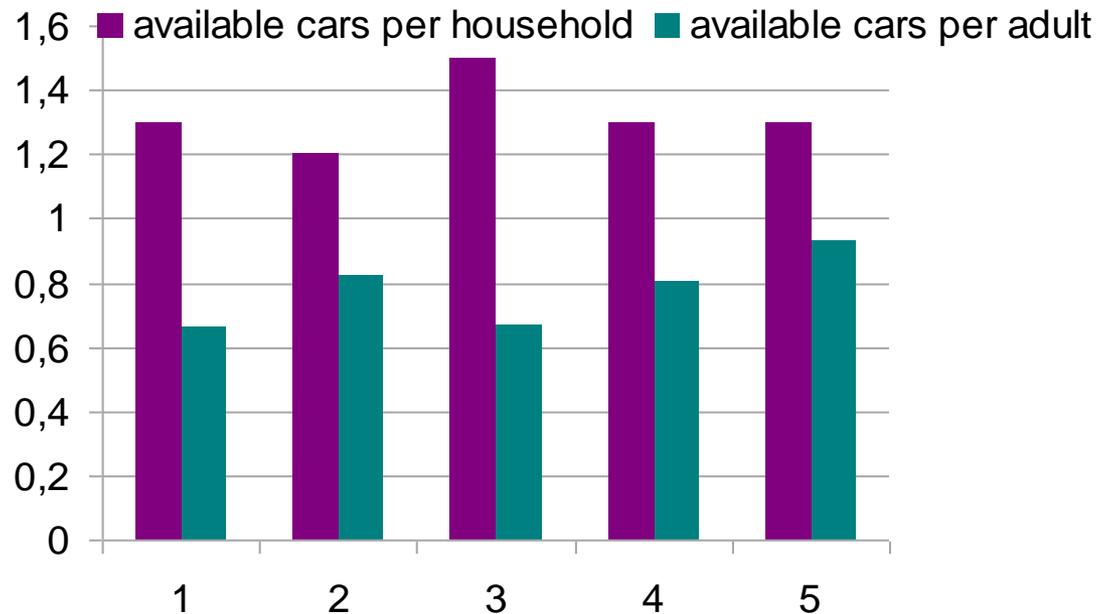
Car availability per household is approximately the same in every income group
=> on average every German household has around 1.3 cars

Car availability per adult increases with increasing income
=> lowest income group: two persons usually share one car
=> highest income group: every person of the household has his own vehicle

Characteristics of the households - Engine size
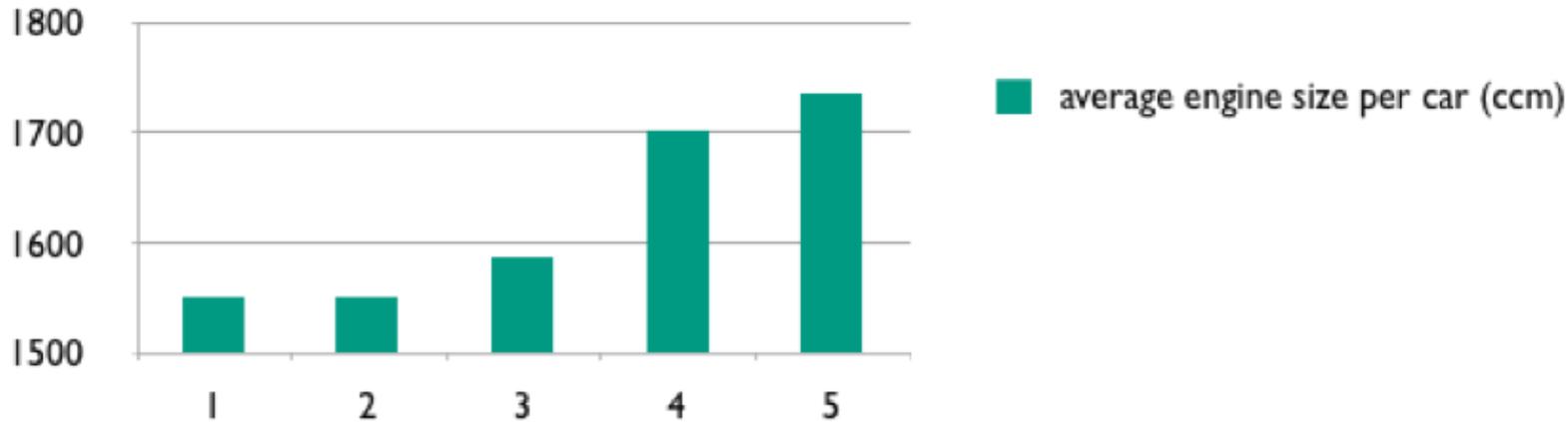
- Upper income groups tend to have **more powerful engines** than lower income groups, but **differences are rather small**

- Possible reasons:
  - higher income groups often have **second cars** with lower engine size;
  - low income households often possess **old cars** with higher cylinder capacity

=> **motor vehicle tax does not reduce inequalities!**

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Impacts of the 4 Road Pricing scenarios

Distributional impacts of Road Pricing

■ Scenario A   ■ Scenario B   ■ Scenario C   ■ Scenario D
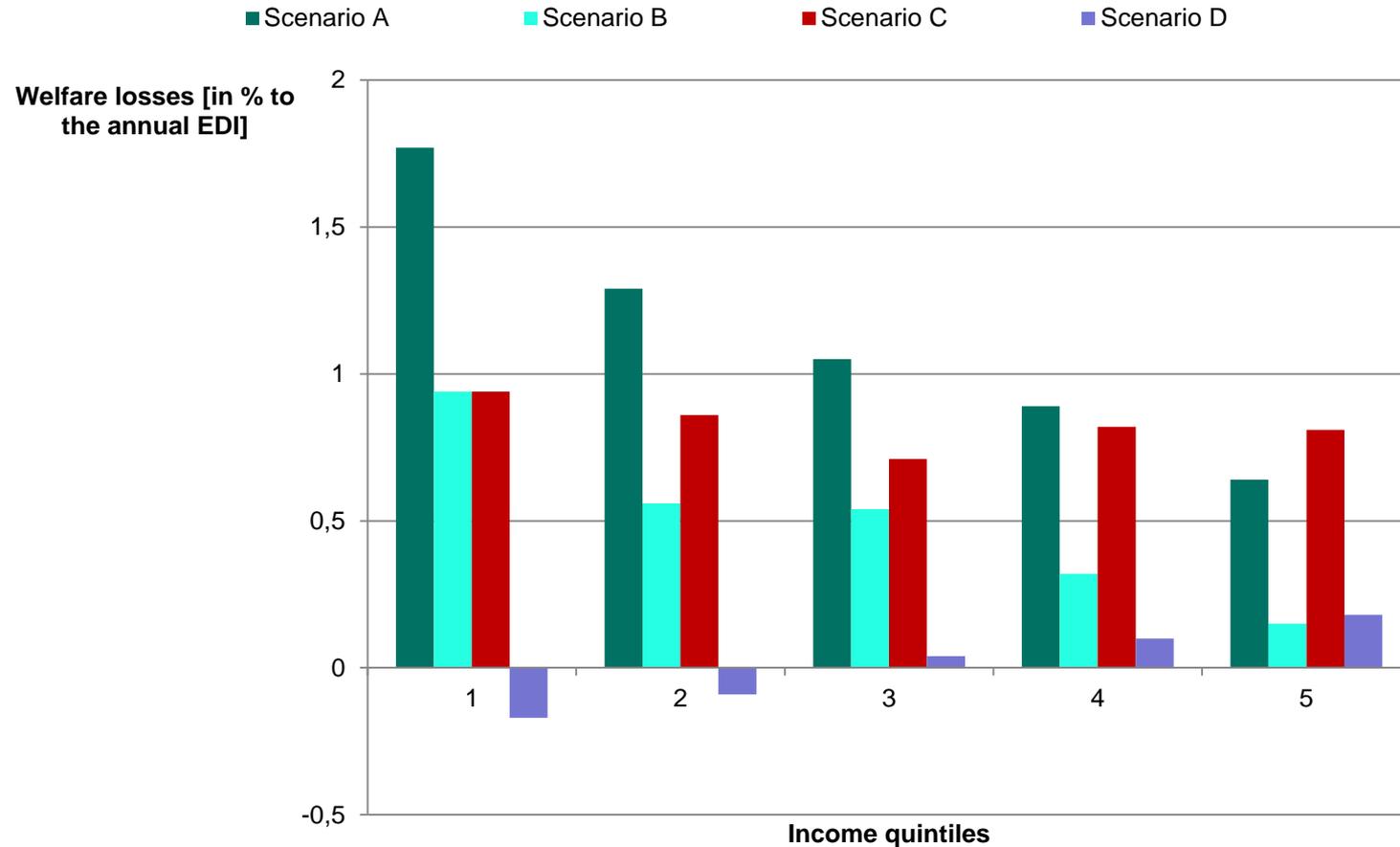
Scenario A – time based without comp.
Scenario C – distance without comp.

Scenario B – time based with comp
Scenario D – time based with with

Impacts of the scenarios

Scenario A

➡️ relative **welfare losses** across all income groups

➡️ **regressive distributional outcome**: the higher the mileage, the lower the relative welfare loss

➡️ especially **families with children** will be **affected negatively**

➡️ better situated **single- or couple-households are nearly not affected**

Scenario B

➡️ relative **welfare losses** but compensation counterbalances road charges

(especially for users in the higher income groups) !

=> **regressive distributional effects** are not avoided

➡️ Assuming higher compensations

=> poorer households could be compensated, but richer households would even realize welfare gains!

=> **additional revenues for the public budget!**

Impacts of the scenarios

Scenario C

➡ relative **welfare losses** across all income groups are distributed uniformely:

user with higher annual mileage have to **pay more** than other income groups

=> **cost-by-cause principle**

➡ **users with higher mileage are usually better earning households!**

Scenario D

➡ nearly a **neutral effect**!

=> all households (independent of the income groups) are brought back to the level of utility as they had before the implementation

➡ especially better situated **single- and couple-households** are affected by road user charges but relative **welfare losses are rather small!** (0.04 to 0.18 % of EDI)

Conclusions

- Distributional impacts of road user charges are **highly dependent on the structure of the pricing scheme** and the **way compensations are ascertained**.

  - **Time-base schemes** (e.g. Vignette) has
    - **regressive effects**
    - => **social concerns** can be confirmed: beneficiaries are usually well-situated single- and couple-households

  - **km-based schemes** guarantees
    - the **cost-by-cause principle**
    - => every user only pays for the km driven on motorways
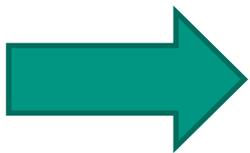
A km-based road pricing scheme WITH compensations can be regarded as socially balanced and does not impact "the poor" disproportionately high!

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