
Integrated Modelling of Land Use and Transport in Regions
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Model levels

Trends

Land use in Germany 1960-2004

Car ownership in Germany 1960-2006

Mobilität in Deutschland 1976-2008

Theory
"How accessibility shapes land use" (Hansen, 1956)

![Accessibility graph](image)

Accessibility of jobs $A_i$

**Time Geography** (Hägerstrand, 1970)

*Action space*: the set of *spatial opportunities* available to an individual

*Constraints* of the action space:
- **Capacity constraints**: a-spatial personal constraints to mobility, such as monetary and time budgets
- **Coupling constraints**: restrictions on the linking of activities
- **Institutional constraints**: restrictions of access due to opening hours or entrance fees.

**Action spaces: family** (Dicken and Lloyd, 1981)

![Action space diagram](image)

**Unified Mechanism of Travel** (Zahavi, 1981)

Based on travel data of more than 100 urban regions, Zahavi (1981) proposed the following hypotheses:

1. Households consider in their daily travel decisions *monetary* and *time budgets*.
2. Monetary and time budgets available for transport change only very slowly.
3. Within their monetary and time budgets households maximise spatial opportunities (i.e. travel distances).

This implies:

- If travel becomes *faster* or *less* expensive, people will make *more* and *longer* trips.
- If travel becomes faster or less expensive, people will choose *more distant* locations.
- If people will get more *affluent*, they will make more and longer trips and choose more distant locations.
- If people have to *work less*, they will make more and longer trips and choose more distant locations.
- If all this happens together, people will make more and longer trips and choose more distant locations.

**Land-use transport feedback cycle**

![Feedback cycle diagram](image)

**Urban systems**

![Urban systems diagram](image)

**Speed of change**

- **Goods transport**: Very fast
- **Travel**: Very fast
- **Population**: Medium
- **Employment**: Slow
- **Workplaces**: Very slow
Urban models today

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Dortmund model

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Dortmund model

The transport model of the Dortmund model

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Dortmund model tools

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Validation

Work trips

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The Dortmund Model

The recursive structure of the Dortmund model

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Dortmund model tools

STEPs Project: Dortmund Region

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Scenarios

The STEPs scenarios combined three rates of energy price increases with three sets of policies:

<table>
<thead>
<tr>
<th>Energy Price Increase</th>
<th>Policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1% p.a.</td>
<td><strong>A-1</strong> Do-nothing</td>
</tr>
<tr>
<td>+4% p.a.</td>
<td><strong>B-1</strong> Business as usual</td>
</tr>
<tr>
<td>+7% p.a.</td>
<td><strong>C-1</strong> Infrastructure &amp; technology</td>
</tr>
</tbody>
</table>

**Demand regulation**
- Fuel tax (up to +4.7 p.a.)
- Road pricing (+2% to +6% p.a.)
- Traffic calming (car speed up to -2.0% p.a.)
- Car-sharing (cars up to -0.6% p.a.)
- Telework (up to -0.3% less work trips in 2030)
- Land use planning (polycentric/compact)
- Public transport fares (up to -1.7% p.a.)

**All policies**

Economic impacts for the Dortmund region

According to the SASI model, the fuel price increases and related policies of the scenarios have significant negative impacts on the economy of the Dortmund urban region:

**Highways**

**Public transport**
Mobility

Share of walking and cycling trips (%)
Share of public transport trips (%)
Share of car trips (%)

Average trip speed (km/h)
Average trip distance (km)

Land Use

Land use scenarios

<table>
<thead>
<tr>
<th>Fuel price increase</th>
<th>+1% p.a.</th>
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<tr>
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<tr>
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<td>A0</td>
<td>B0</td>
<td>C0</td>
</tr>
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<td>A1</td>
<td>B1</td>
<td>C1</td>
</tr>
<tr>
<td>Demand regulation</td>
<td>A2</td>
<td>B2</td>
<td>C2</td>
</tr>
<tr>
<td>All policies</td>
<td>A3</td>
<td>B3</td>
<td>C3</td>
</tr>
</tbody>
</table>

Population

Scenario B3 compared to Scenario A-1 in 2030 (%)
Scenario C3 compared to Scenario A-1 in 2030 (%)
Impacts of land use on travel
High-density mixed-use urban forms have a significant impact on travel distance.

![Travel distance by car per capita per day (km)](image)

Impacts of land use on travel
High-density mixed-use urban forms have a significant impact on choice of mode.

![Share of car trips (%)](image)

Environment

Traffic accidents per 1,000 inhabitants per year

![Traffic accidents per 1,000 inhabitants per year](image)

Fuel consumption per car trip per traveller (litres)

![Fuel consumption per car trip per traveller (litres)](image)

CO₂ emission by transport per capita per day (kg)

![CO₂ emission by transport per capita per day (kg)](image)

Mobility impacts
Fuel price increases will lead to significant changes in daily travel behaviour.

The long-term trend towards more and longer trips and more trips by car will be stopped or even reversed. Average travel distances per capita will return to the level of the 1990s, average travel distances by car to the level of the 1980s and before.

There will be a renaissance of walking and cycling, and the share of public transport trips will more than double. The share of car trips will decline to that of the 1970s.

Conclusions
Social impacts
These changes in travel behaviour will not be voluntary but **forced responses to severe constraints** and will imply a substantial loss of **quality of life**.

The reductions in trips and trip distances will affect **social or leisure trips** most: every such trip not made will mean a friend not visited, a meeting not attended or a theatre performance or soccer match not seen.

Rising costs of transport will mean also **financial stress** for households, who will have to spend more on travel than before, although their income will grow less.

Environmental impacts
The positive side-effects of rising fuel prices will be their **environmental effects**.

Every car trip not made and every kilometre the remaining trips will be shorter will mean less **greenhouse gases, air pollution and accidents**.

The efforts to develop more **energy-efficient cars** and **alternative vehicles** stimulated by fuel price increases will contribute to the positive environmental balance.

From the point of view of **climate protection**, high fuel prices are the best possible prospect.

Future work
In addition to the aggregate scenario results presented, the following aspects should be studied:
- impacts of energy price increases on:
  - **industries** (e.g. retail, tourism, transport)
  - **office and housing** markets (vacancies, rents)
  - **distributive** fairness (social and spatial)
  - **access** to basic services (e.g. retail, health care)
  - **environment** (e.g. noise, air quality, biodiversity)
- interactions between policy responses:
  - **counteracting** effects
  - **reinforcing** effects (synergies)

Urban models and the energy transition
During and after the energy transition, energy for transport will be no longer **abundant and inexpensive** but **scarce** and **expensive**.

This will have fundamental consequences for **mobility** and **location** behaviour in cities.

Urban models that are calibrated on **past** behaviour and/or do not explicitly consider the **cost** of transport and location relative to household income are not able to forecast these changes.

They will tend to **underestimate** the behavioural response of households and predict that households will **overspend** their money travel budgets.

Urban models and fundamental change
The **fundamental changes** in the problems and priorities of urban planning due to **climate protection** and the **energy transition** will have **deep impacts** on the **philosophy** and **method** of urban modelling:
- **less extrapolation**, more **fundamental** change
- **less equilibrium**, more **dynamics**
- **less observed** behaviour, more **theory** on needs
- **less preferences** and **choices**, more **constraints**
- **less calibration**, more **plausibility analysis**
- **less detail**, more basic **essentials**
- **less forecasting**, more **backcasting** (don't ask what could be done but what needs to be done)