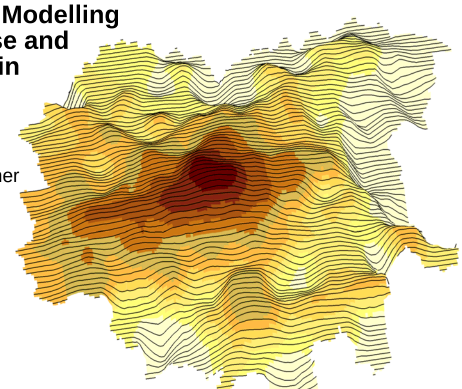
Integrated Modelling of Land Use and Transport in Regions

Michael Wegener



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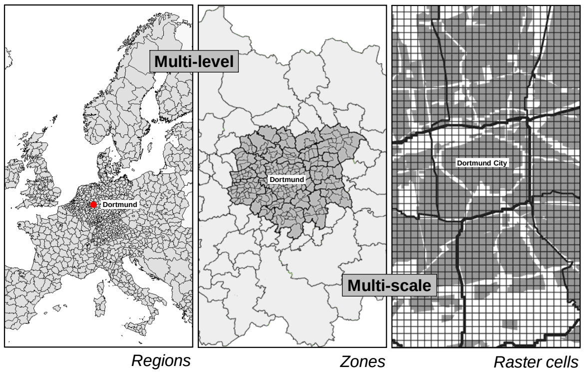
Model levels



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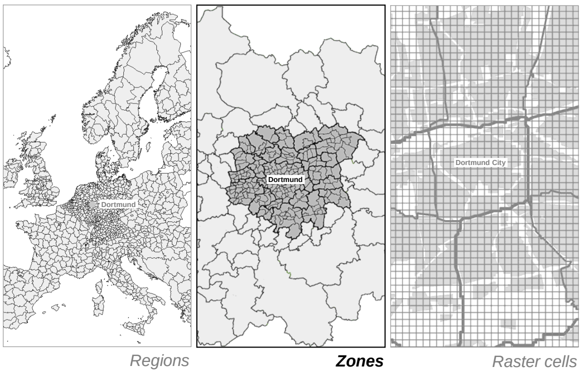
Model levels



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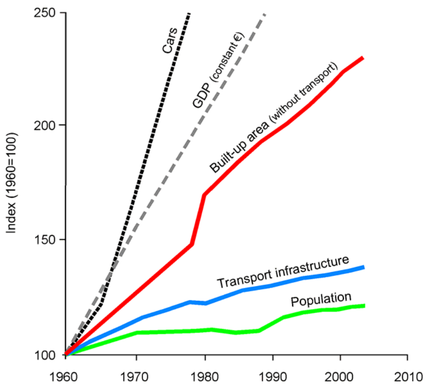
Trends

Land use in Germany 1960-2004

Sources: Statistisches Bundesamt: Statistisches Jahrbuch 2007; BBR (2005): Raumordnungs-bericht 2005; DIW (2005): Verkehr in Zahlen 2005/2006



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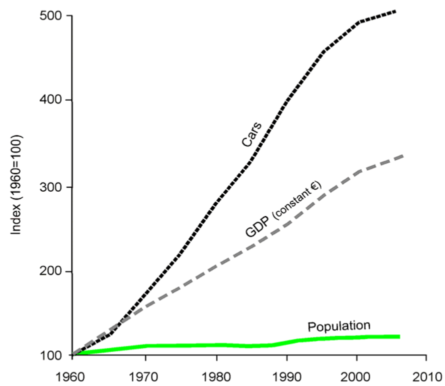
Car ownership in Germany 1960-2006

Sources: Statistisches Bundesamt: Statistisches Jahrbuch 2007; DIW (2005): Verkehr in Zahlen 2005/2006



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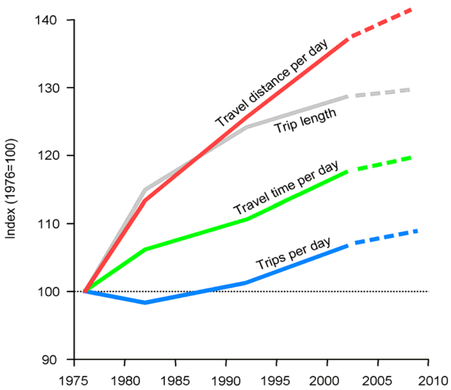
Mobilität in Deutschland 1976-2008

Sources: KONTIV 1976; KONTIV 1982; BMV 1992; MiD 2002; MiD 2008 (prelim.)



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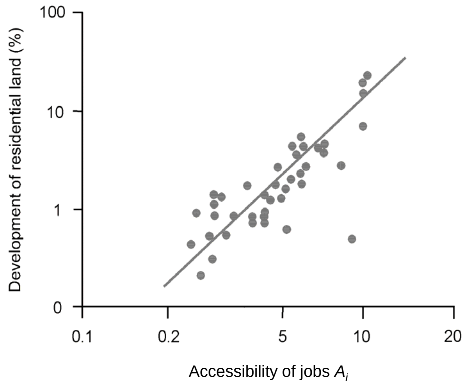
Theory

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



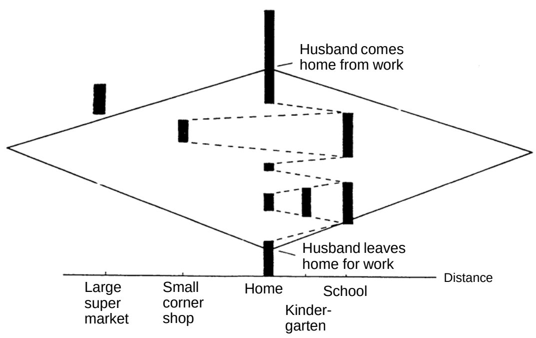
Time Geography (Hägerstrand, 1970)

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)*



Unified Mechanism of Travel (Zahavi, 1981)

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

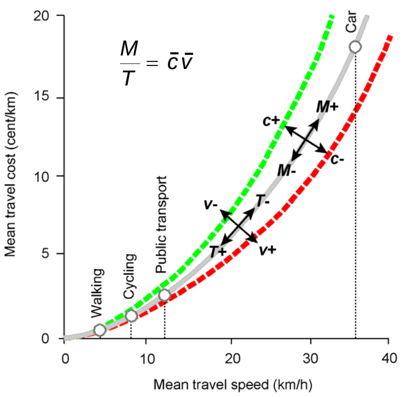
(1) Households consider in their daily travel decisions ***monetary*** and ***time budgets***.

(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).

Unified Mechanism of Travel (Zahavi, 1981)

Impact of transport measures on mean travel cost and speed

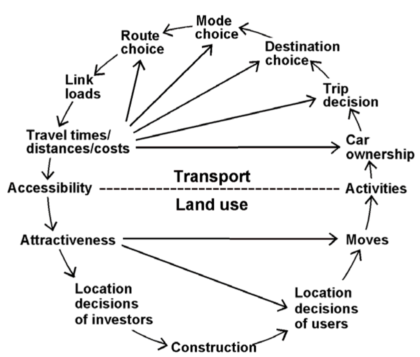


M Travel cost budget
T Travel time budget
$\bar{c}$ Mean cost per km
$\bar{v}$ Mean speed

This implies:

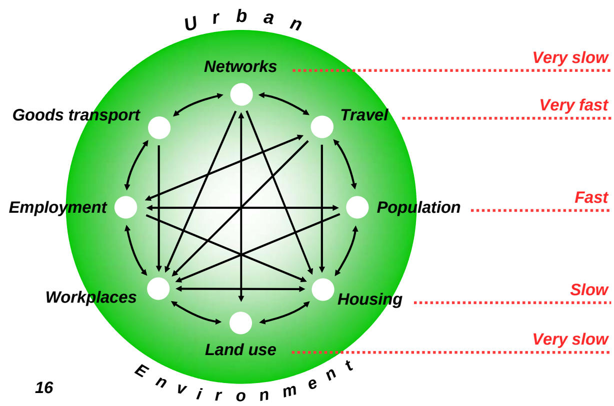
- If travel becomes ***faster*** or ***less*** expensive, people will make ***more*** and ***longer*** trips.
- If travel becomes faster or less expensive, people will choose ***more distant*** locations.
- If people will get more ***affluent***, they will make more and longer trips and choose more distant 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

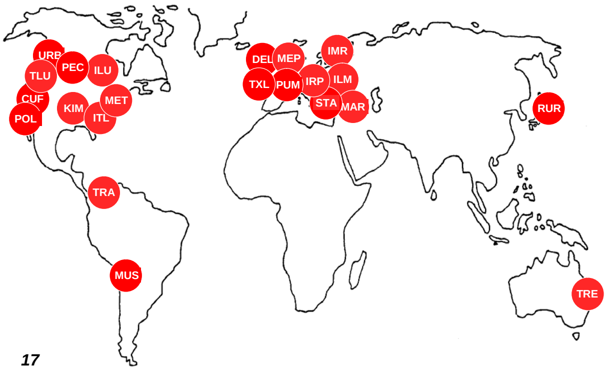


Urban systems

Speed of change



Urban models today



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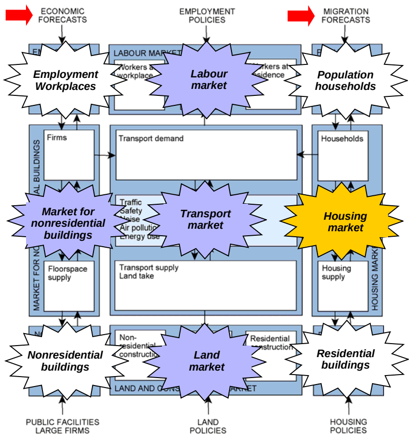
The Dortmund Model

Dortmund model



Forecast of SASI model

Microsimulation

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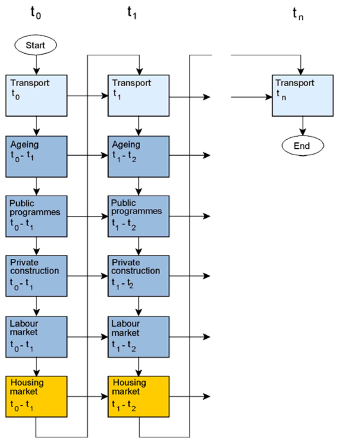
Dortmund model

The recursive structure of the Dortmund model

Equilibrium

Incremental

Microsimulation



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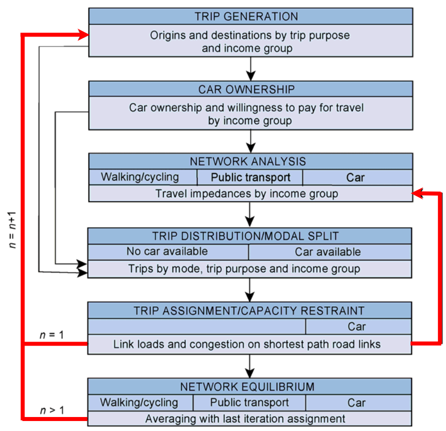
Dortmund model

The transport model of the Dortmund model



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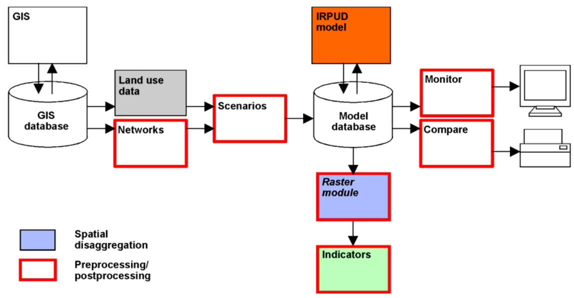
Dortmund model tools



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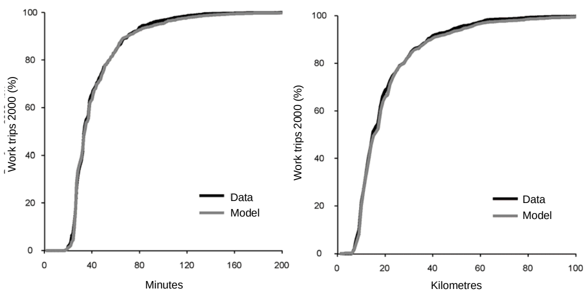
Validation

Work trips



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STEPs Project: Dortmund Region

Scenarios

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

	+1% p.a. (2030: 1.60 €*)	+4% p.a. (2030: 3.33 €*)	+7% p.a. (2030: 6.80 €*)
Do-nothing	**A-1**	**B-1**	**C-1**
Business as usual	**A0**	**B0**	**C0**
Infrastructure & technology	**A1**	**B1**	**C1**
Demand regulation	**A** (2030: 3.35 €*)	**B** (2030: 6.95 €*)	**C** (2030: 23.25 €*)
All policies	**A3**	**B3**	**C3**

* € of 2008 per litre   A-1 *Reference Scenario*

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Policy scenarios

A1-C1 Infrastructure and technology
- More energy-efficient cars (fuel -0.5% to -3.0% p.a.)
- Alternative vehicles/fuels (2% to 30% in 2030)
- Public transport speed (up to +1.7% p.a.)

A2-C2 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.)

A3-C3 All policies

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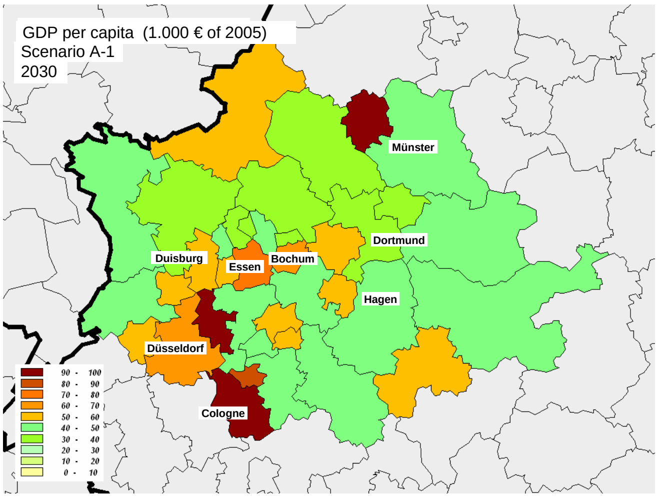
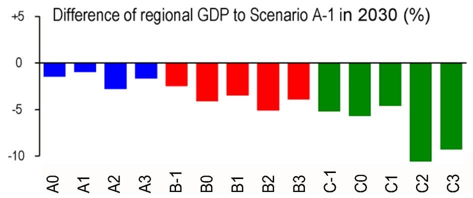


Economic impacts for the Dortmund region

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:



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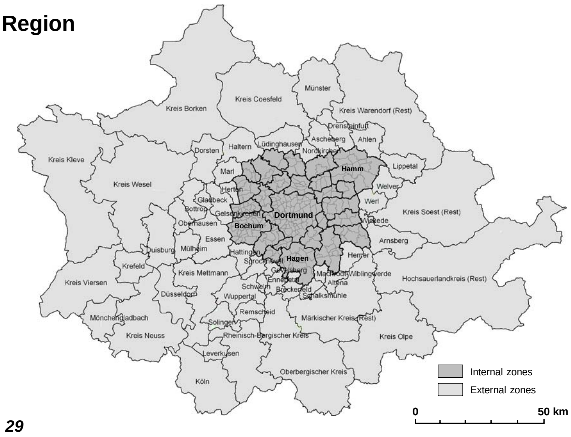
Region



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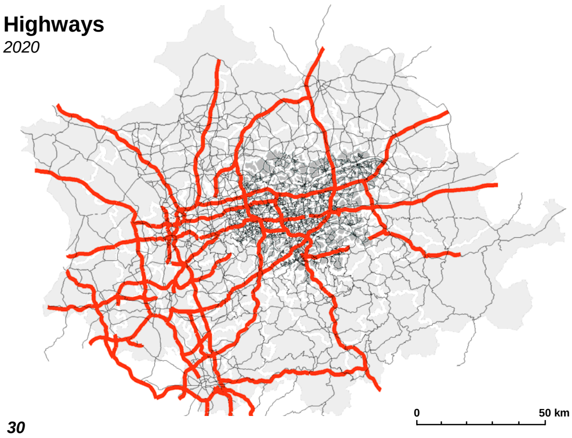
Highways

2020



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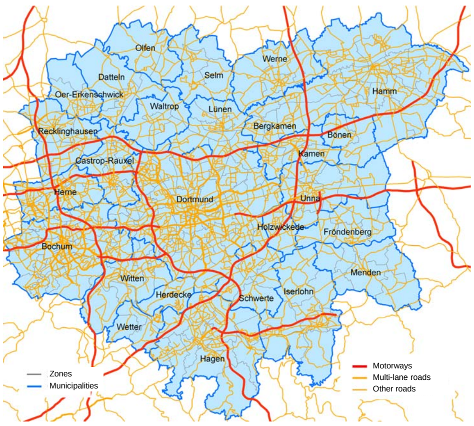
Highways

2000



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Public transport

2000

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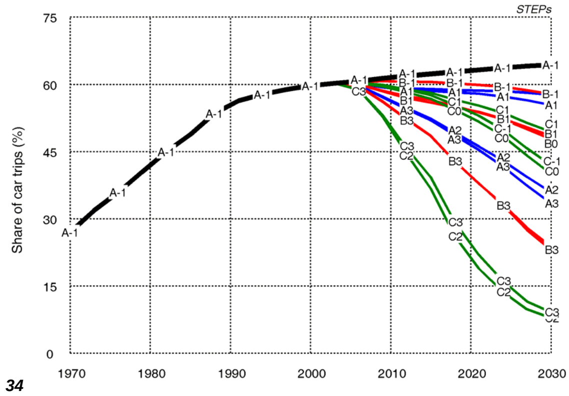
Mobility

Share of car trips (%)



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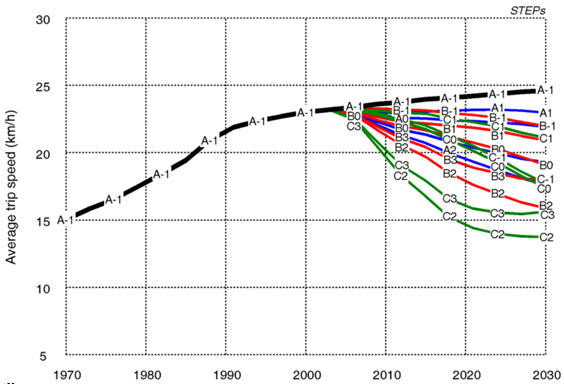
Average trip speed (km/h)



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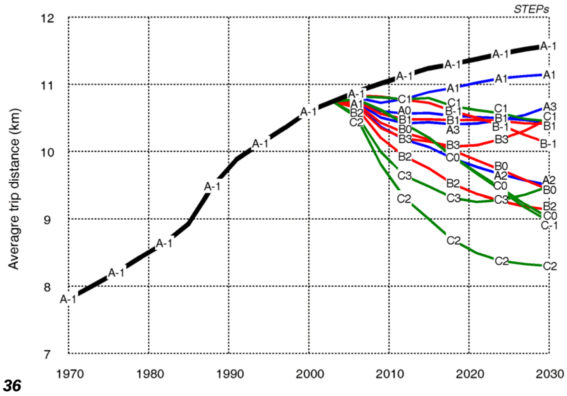
Average trip distance (km)



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Land Use

Land use scenarios

	Fuel price increase		
	+1% p.a.	+4% p.a.	+7% p.a.
Do-nothing	A-1	B-1	C-1
Business as usual	A0	B0	C0
Infrastructure & technology	A1	B1	C1
Demand regulation	A2	B2	C2
All policies	A3	B3	C3

Business as usual | Polycentric | Compact city

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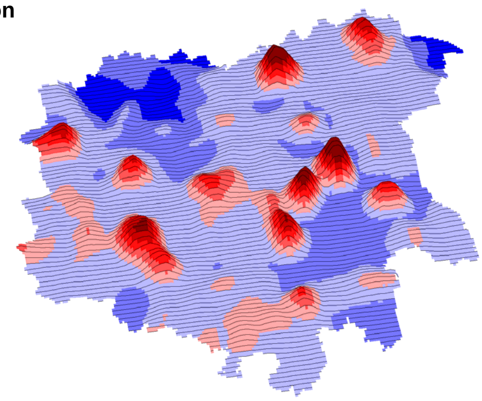
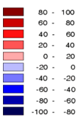
Population

Scenario B3
compared to
Scenario A-1
in 2030 (%)

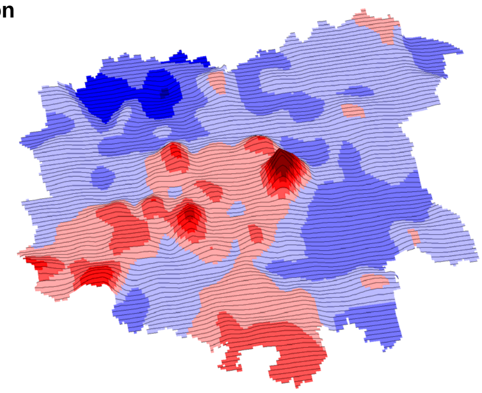


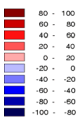


Polycentric

Population

Scenario C3
compared to
Scenario A-1
in 2030 (%)

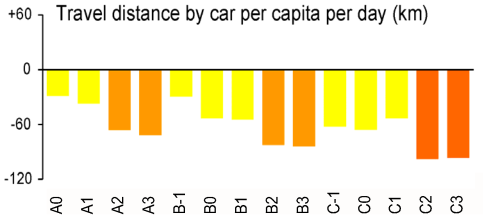




Compact city

Impacts of land use on travel

High-density mixed-use urban forms have a significant impact on ***travel distance***:



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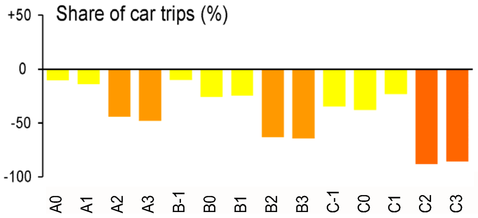
Impacts of land use on travel

High-density mixed-use urban forms have a significant impact on ***choice of mode***:



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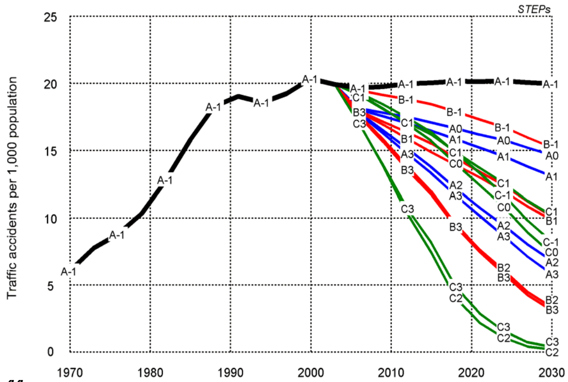
Environment

Traffic accidents per 1,000 inhabitants per year



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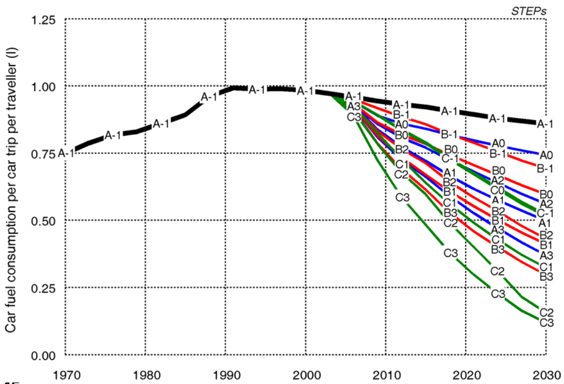
Fuel consumption per car trip per traveller (litres)



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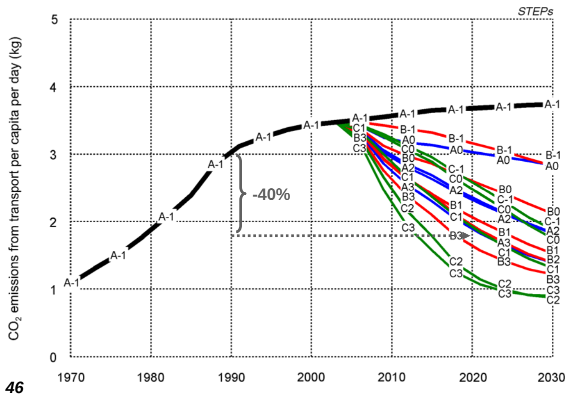
CO_2 emission by transport per capita per day (kg)



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Conclusions

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.

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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.

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Land use impacts

European cities have a great potential for a better spatial co-ordination of activities by ***internal reorganisation***.

When mobility becomes more expensive, ***accessibility*** will again become an important location factor: households will move closer to their workplaces and firms will move closer to their workers, suppliers and customers.

Daily life will become again more ***local***. Destinations farther away will be replaced by nearer ones which can be reached on foot or bicycle. ***Neighbourhood*** relations, frequently forgotten in a super-mobile world, will become valued again.

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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.

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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)

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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.

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Urban models and the energy transition

In order to adequately deal with significantly rising energy costs of transport, urban models must primarily address ***basic needs*** of households that can be expected to stay ***constant over time***, such as

- ***shelter*** and ***security*** at the place of residence (space, recreation, health),
- ***access*** to necessary activities (work, education, retail, services).

and consider the constraints of ***housing*** and ***travel costs*** in relation to household ***income***.

Action space theory taking into account both ***time*** and ***money budgets*** may be a way to achieve this.

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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)

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More information

Fiorello, D., Huismans, G., López, E., Marques, C., Steenberghen, T., Wegener, M., Zografos, G. (2006): *Transport Strategies under the Scarcity of Energy Supply*. STEPs Final Report, edited by A. Monzon and A. Nuijten. Den Haag: Bucks Consultants. *http://www.steps-eu.com/reports.htm*.

STEPs (2006): *Scenario Impacts*. STEPs Deliverable D4.2. Mailand: Trasporti e Territorio SRL. *http://www.spiekermann-wegener.de/pro/pdf/STEPs_D4_2.pdf*.

More information on the Dortmund model and its applications can be found at http://www.spiekermann-wegener.de/mod/irpudmod_e.htm.

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