Multi-scale spatial models: linking macro and micro

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Integrated land-use transport models
Today’s integrated land-use transport models suffer from several weaknesses:
- Their classification of households and individuals is too crude; individual lifestyles cannot be represented.
- Their transport models are not activity-based and cannot address “soft” transport policies.
- Their spatial resolution is too coarse to take account of small-scale local policies.
- Forecasting environmental impacts such as air pollution, land take and traffic noise is difficult, modelling environmental feedback is impossible.
- Issues of spatial equity cannot adequately be addressed.

Microsimulation
New activity-based microsimulation models improve urban simulation models:
- Individual lifestyles can be represented, households and individuals are disaggregated to the agent level.
- Environmental impacts can be modelled with the required spatial resolution.
- Environmental feedback between environment and land use and transport can be modelled.
- Microlocations can be represented. Households affected by environmental impacts can be localised.

However ...
To date, no full-scale microsimulation model of urban land use, transport and environment has become operational.
There are still unresolved problems regarding the interfaces between the submodels.
The feedback between transport and location and environmental quality and location has not yet been implemented.
Serious problems of calibration, stability and stochastic variation have not been solved.
The computing time for existing models is calculated in terms of weeks or days, not hours.

How much micro is enough?
Despite these problems, microsimulation modellers engage in ever more ambitious plans to further raise the complexity and spatial resolution of their models.
The common belief among most microsimulation modellers seems to be: the more micro the better.
This is the dream of the one-to-one Spitfire.

The one-to-one model of the Spitfire

“Theone-to-one model of the Spitfire

“Simplifying assumptions are not an excrescence on model-building; they are its essence. Lewis Carroll once remarked that a map on the scale of one-to-one would serve no purpose. And the philosopher of science Russell Hanson noted that if you progressed from a five-inch balsa wood model of a Spitfire airplane to a 15-inch model without moving parts, to a half-scale model, to a full-size entirely accurate one, you would end up not with a model of a Spitfire but with a Spitfire”.

Robert M. Solow (1973)
How much micro is enough?
There seems to be little consideration of the benefits and costs of microsimulation:
- Where is microsimulation really needed?
- What is the price for microsimulation?
- Would a more aggregate model do?
For spatial planning models, the answer to these questions depends on the planning task at hand.
For instance, for modelling the impacts of transport on land use, much simpler travel models are sufficient.

Macro or micro?
These considerations lead to a reassessment of the hypothesis that eventually all spatial modelling will be microscopic and agent-based.

Conclusions (1)
Only integrated microsimulation land-use transport models permit the modelling of
- "soft" and local planning policies
- individual lifestyles
- environmental impacts and feedback
- microlocations and spatial equity.
However, there is a price for the microscopic view in terms of data requirements and long computing times.
There are privacy concerns and ethical issues involved.

Conclusions (2)
Under constraints of data collection and of computing time, there is for each planning problem an optimum level of conceptual, spatial and temporal resolution.
This suggests to work towards a theory of balanced multi-scale models which are as complex as necessary for the planning task at hand and as simple as possible but no simpler.
Future urban models will be modular and multi-scale in scope, space and time.

Multi-Scale Modelling
The Dortmund Example

Model levels
Level 1: Regions
The STEPs Project (2004-2006)

The EU 6th RTD Framework project STEPs (Scenarios for the Transport System and Energy Supply and their Potential Effects) developed and assessed possible scenarios for the transport system and energy supply of the future.

In the project five urban/regional models were applied to forecast the long-term economic, social and environmental impacts of different scenarios of fuel price increases and different combinations of infrastructure, technology and demand regulation policies.

Here the model results for the urban region of Dortmund, Germany, will be presented.

The STEPs Project: Scenarios

The project developed a set of scenarios assuming different rates of energy price increases with three sets of policies:

<table>
<thead>
<tr>
<th>Fuel price increase</th>
<th>+1% p.a.</th>
<th>+4% p.a.</th>
<th>+7% p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do-nothing</td>
<td>A-1</td>
<td>B-1</td>
<td>C-1</td>
</tr>
<tr>
<td>Business as usual</td>
<td>A0</td>
<td>B0</td>
<td>C0</td>
</tr>
<tr>
<td>Infrastructure &amp; technology</td>
<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>

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:
The ILUMASS Project (2001-2006)

The project ILUMASS (Integrated Land-Use Modelling and Transport Systems Simulation) embedded a microscopic dynamic simulation model of urban traffic flows into a comprehensive model system incorporating both changes of land use and the resulting changes in transport demand as well as their environmental impacts.

For testing the land use submodels, the transport and environmental submodels were replaced by the \textit{aggregate transport model} of the IRPUD model and simpler environmental impact models (= \textit{reduced ILUMASS model}).

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**Firms and households**

Select a firm

Check satisfaction with present location

Satisfied?

No

Yes

Another firm?

Yes

No

Select alternative location

Accept?

No

No

Yes

Update lists

- Firms
- Nonresidential floorspace
- Employed persons

Select a household

Demographic events

- Ageing
- Death
- Birth
- Marriage/cohabitation
- Divorce/separation
- Persons leave household
- Persons move together

Economic events

- Education
- Place of work
- Employment status
- Income
- Mobility budget of household

Update lists

- Persons
- Households
- Dwellings
- Firms

Start

End

Another household?

Yes

No
Mean traffic noise exposure (Raster)

Mean traffic noise (Zone)

Zone v. Raster
Traffic noise

Reduced ILUMASS model

Model dimensions
1.2 million households
2.6 million persons
1.2 million dwellings
80,000 firms
92,000 industrial sites
8,400 public transport links
848 public transport lines
13,000 road links
246/54 internal/external zones
209,000 raster cells
30 simulation periods (years)
90 minutes computing time

Typical Model Run

Model parameters

Micro data

Travel flows

Travel flows

