Data, data structures and models

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Data, data structures and models

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Kurzfassung


Voraussetzung für diese Analysen ist eine Angleichung der entsprechenden Erhebungen. Die Angleichung besteht aus der Erstellung eines gemeinsamen Variablensatzes, wobei zwischen räumlichen, Haushalts- und Personenvariablen unterschieden wird, sowie aus der Harmonisierung der gewählten Variablen.

Schlagworte

Xyz – Xyz – Xyz – ETH Zürich – Institut für Verkehrsplanung und Transporttechnik, Strassen- und Eisenbahnbau (IVT)

Zitiervorschlag:
Data, data structures and models

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June 2002

Abstract

In this paper travel surveys from Europe, America and Asia are compared. Besides descriptive statistics models are developed, which are based on the SEM-method respectively the MLM-method. The models give information about the structures between the variables.

Precondition for these analyses is the adaptation of the respective surveys. The adaptation consists of the preparation of a spatial, a household and a person file as well as of the harmonisation of the selected variables.

Keywords

Xyz – Xyz – Xyz – ETH Zürich – Institut für Verkehrsplanung und Transporttechnik, Strassen- und Eisenbahnbau (IVT)

Preferred citation style:

1. Introduction

Reinforcing the separation of daily activities at ever-increasing distances, the growth in motorised travel has generated an increasing number of social problems at a growing scale. Today, transportation activities create externalities at virtually all aggregation levels, i.e. urban (land-use, congestion, urban air pollution), regional (acid rain, ozone), and (inter-)national (emissions of greenhouse gases). Policy makers worldwide trying to cope with these problems need to base their decisions on sound analyses of travel behaviour; unfortunately, no such fundamental comparative large-scale studies exist to date.

However, a profound understanding of mobility patterns and their underlying forces would be crucial for formulating effective sustainable transportation policies. The first step in this direction is a systematic examination of a large number of urban and national travel surveys that (1) might reveal the existence of regularities in travel demand over space and time, (2) indicate the extent to which travel patterns differ across different settings with respect to land-use (or population density), transport infrastructure and services, economic structure and culture. Based on (1) and (2) the formulation of more appropriate policies to induce a shift toward more sustainable travel patterns is possible.

To ensure the broadest possible approach, data covering urban, suburban and rural areas from as many continents as possible should be analysed. The comparability of the different surveys is a precondition for their common analysis. Therefore it is necessary to adapt the different survey approaches and to harmonise the different variables. An overview of the proposed surveys, a list of potential variables and first calculations are the contribution of this paper to the project 'fundamental patterns of travel behaviour and their policy implications for land-use, congestion, and air-quality'.

2. State of the art

While no study exists that would have examined these questions in the same proposed breadth, a few studies have examined details of these questions. Some have dealt with a specific component of the questions raised above; Newman and Kenworthy (1989, 1999), for
example, have examined the interaction of urban land-use and transportation energy consumption in great detail for a number of cities from the developed and developing world. Other studies have mainly quantified the major travel characteristics such as the number of trips by mode and purpose (Schipper, Figueroa and Gorham, 1995), while again other studies focussed on individual countries. Among those, Salomon, Bovy and Orfeuil (1993) offer the broadest analysis; but their studies of European transportation systems does not attempt to quantify relationships between mobility parameters and across countries.

It is indeed surprising, how little work has been done to model national travel surveys, either individually or comparatively; only the recent availability of advanced modelling software is starting to change this situation. More recently, Schafer (2000) has made a first approach in this direction; however, as he points out, more travel surveys and data harmonisation are needed. In addition, Alves and Axhausen (1994) analysed the stability of daily activity chains and daily modal chains across five countries and highlighted the country specific differences at a national level. The methodological issues inherent in measuring travel behaviour were the focus of Axhausen (1995, 1999 and 2001).

Based upon person trip surveys in a large number of Japanese cities, Katiyar and Ohta (1992) investigated trip-making behaviour in light of the travel time budget; their analysis suggested a relative stability of trip rate and travel time budget. In developing countries, where the limited availability of reliable data has resulted in only few analyses, Furutani, Muromachi, Harata and Ohta (1999) conducted a full-scale study on commuting pattern in Bangkok and compared those to the Tokyo metropolitan area. Analysing the relationship of travel patterns and urban spatial structure in both cities, they concluded that a reduction in vehicle-miles of travel could be achieved by co-ordinating land use and transport systems.

3. Travel Surveys

Each of the mentioned surveys (see Table 1) contains information about travel behaviour, the respective persons and households and was conducted at least once in the last ten years. For all surveys it is possible to add area information. But there are differences in the survey approaches, in the number of surveys, in the sample size, in the geographic scale, in the reporting period and time.
• **Approaches**: In all surveys information about travel behaviour is collected by trip diaries whereby the length of the diaries differ. Most surveys contain only one day - some only weekdays, some all days of a week. There is one survey with a six week trip diary (Axhausen, Zimmermann, Schönfelder, Rindsfüser and Haupt, forthcoming).

• **Sample size**: Most nation wide surveys have rather large samples because they should be representative. Unique is the Upper Austria Travel Survey with a sample size of 300'000 persons and the inclusion of each municipality.

• **Year(s)**: Most of the surveys were conducted more than once. Especially the nation wide surveys (NTS, NTPS, Kontiv or Mikrozensus) already started in the seventies - however often only summary statistics of these first surveys are available - and were repeated in the following decades.

• **Reporting period**: The survey periods of the nation wide surveys mostly cover the whole year. The other surveys are either conducted in spring or in autumn.

• **Geographic scale**: Various variables are included in these surveys. These variables are grouped into different files for clarity. The person file contains information about the socio-demographic characteristics and the commitment situation, the person day file contains summaries of travel behaviour, the household file contains information about the household, the accessibility of facilities and of public transport, the vehicle file contains information about the type and the usage of the car, the area file contains spatial information.
<table>
<thead>
<tr>
<th>Area</th>
<th>Name</th>
<th>Year</th>
<th>Reporting period</th>
<th>Survey period</th>
<th>Geographic scale</th>
<th>Sample size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Europe</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>Kontiv</td>
<td>1982, 89-90</td>
<td>One day</td>
<td>Whole year</td>
<td>Urban / rural</td>
<td>89-90: 40'000 persons</td>
<td>2001-02 ongoing, earlier survey exists</td>
</tr>
<tr>
<td>Germany</td>
<td>Panel</td>
<td>1994 - ongoing</td>
<td>One week</td>
<td>Autumn</td>
<td>Urban / rural</td>
<td>600 new persons per wave</td>
<td>3 years per household</td>
</tr>
<tr>
<td>Germany</td>
<td>Mobidrive</td>
<td>1999</td>
<td>Six weeks</td>
<td>Autumn</td>
<td>Urban / rural</td>
<td>360 persons</td>
<td>Quoted sample</td>
</tr>
<tr>
<td>UK</td>
<td>NTS</td>
<td>1972, 75-76, 78-79, 85-86, 88-98</td>
<td>One week</td>
<td>Whole year</td>
<td>Urban / rural</td>
<td>96-98: 15'000 persons</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Mikrozensus</td>
<td>1994</td>
<td>One day</td>
<td>Whole year</td>
<td>Urban / rural</td>
<td>15'000 persons</td>
<td>2001 ongoing, earlier surveys exist</td>
</tr>
<tr>
<td>Upper Austria</td>
<td>Travel Survey</td>
<td>1982, 92, 2002</td>
<td>One day</td>
<td>Autumn</td>
<td>Urban / rural</td>
<td>1992: 300'000 persons</td>
<td>Each municipality included in the sample</td>
</tr>
<tr>
<td><strong>America</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>NPTS</td>
<td>1977, 83, 90, 95</td>
<td>One day, 14-day travel questionnaire</td>
<td>Whole year</td>
<td></td>
<td>83: 6'438 households 95: 42'015 households</td>
<td>Earlier survey exists (1969)</td>
</tr>
<tr>
<td>Colombia</td>
<td>Bogatá</td>
<td>1995</td>
<td>One day</td>
<td>Autumn</td>
<td></td>
<td>15'516 households</td>
<td>Earlier survey exists</td>
</tr>
<tr>
<td>Chile</td>
<td>Santiago</td>
<td>1991</td>
<td>One day</td>
<td>Spring</td>
<td></td>
<td>33'000 households</td>
<td>Earlier survey exists</td>
</tr>
<tr>
<td>Oregon</td>
<td>Portland</td>
<td>1994</td>
<td>One day</td>
<td>Spring/ Autumn</td>
<td></td>
<td>8'000 households</td>
<td>4'500 households in the rest of the US</td>
</tr>
<tr>
<td>California</td>
<td>San Francisco</td>
<td>1990, 96</td>
<td>One/multi-day trip diaries</td>
<td>Autumn</td>
<td></td>
<td>90: 10'830 households 96: 5'861 households</td>
<td>Earlier surveys exist</td>
</tr>
<tr>
<td>Asia</td>
<td>Japan NPTS</td>
<td>1999</td>
<td>One weekday and one weekend day</td>
<td>Autumn</td>
<td>500 households / city</td>
<td>98 cities</td>
<td>Earlier surveys exist</td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>---------</td>
<td>---------------------------------</td>
<td>--------</td>
<td>-----------------------</td>
<td>-----------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Japan</td>
<td>One weekday</td>
<td></td>
<td>Autumn</td>
<td></td>
<td>500 households / city</td>
<td>98 cities</td>
<td>Earlier surveys exist</td>
</tr>
<tr>
<td>Bangkok</td>
<td>UTDM/BEIP Combined Home Interview Survey</td>
<td>1995</td>
<td>One weekday</td>
<td>N.A.</td>
<td>7879 households</td>
<td></td>
<td>Earlier surveys don’t exist</td>
</tr>
<tr>
<td>Variable</td>
<td>Germany (Kontiv)</td>
<td>German Panel</td>
<td>Mobi-drive</td>
<td>UK</td>
<td>Switzerland</td>
<td>Upper Austria</td>
<td>U.S. NPTS</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------</td>
<td>--------------</td>
<td>------------</td>
<td>----</td>
<td>-------------</td>
<td>---------------</td>
<td>----------</td>
</tr>
<tr>
<td>Age</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sex</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Personal income</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Formal education</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>License holding</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Marital status</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Personal annual VMT</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Season ticket ownership</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Car availab. / ownership</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Work / school duration</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes²</td>
</tr>
<tr>
<td>Number of jobs</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes³</td>
<td>No⁴</td>
</tr>
<tr>
<td>Type of main job</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No³</td>
<td>No⁵</td>
</tr>
<tr>
<td>Work / school location</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes²</td>
<td>Yes</td>
<td>No⁴</td>
</tr>
<tr>
<td>Nationality / ethnicity</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1. Household car ownership
2. Can be derived
3. As distance from home
4. There is information about the zone, an estimated distance can be calculated.
5. Main job only
Table 3  Proposed person day variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Germany (Kontiv)</th>
<th>German Panel</th>
<th>Mobi-drive</th>
<th>UK</th>
<th>Switzerland</th>
<th>Upper Austria</th>
<th>U.S. NPTS</th>
<th>Santiago</th>
<th>Bogotá</th>
<th>Portland</th>
<th>San Francisco</th>
<th>Japan</th>
<th>Bangkok</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trips(^1)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of journeys(^1)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mode chain</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Activity chain</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sum of travel times(^1)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sum of distances(^1)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No(^3)</td>
<td>No(^3)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sum of activity time(^2)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes(^3)</td>
<td>Yes(^3)</td>
<td>Yes(^3)</td>
<td>Yes(^3)</td>
<td>Yes</td>
<td>Yes(^3)</td>
<td>Yes(^3)</td>
</tr>
<tr>
<td>Sum of trip expenditures</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Partially</td>
<td>No</td>
<td>No</td>
<td>Partially</td>
<td>Yes(^3)</td>
<td>Partially</td>
<td>Yes(^3)</td>
<td>Yes(^3)</td>
</tr>
</tbody>
</table>

\(^1\) Total and by purpose / mode  
\(^2\) Total and by purpose  
\(^3\) Can be derived
Table 4  Proposed household variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Germany (Kontiv)</th>
<th>German Panel</th>
<th>Mobi-drive</th>
<th>UK</th>
<th>Switzerland</th>
<th>Upper Austria</th>
<th>U.S. NPTS</th>
<th>Santiago</th>
<th>Bogotá</th>
<th>Portland</th>
<th>San Francisco</th>
<th>Japan</th>
<th>Bangkok</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of members</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of workers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of infants</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of pupils</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Household income</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Home location</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Accessibility of services</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No$^4$</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Public transport access</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
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<tr>
<td>Nr. of parking spaces</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1 Only for members travelling on survey day
2 There is information about the zone, an estimated distance can be calculated
3 As distance from work, school.
4 But normally used mode to the main purposes
5 Only for LRT

Table 5  Proposed vehicle variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Germany (Kontiv)</th>
<th>German Panel</th>
<th>Mobi-drive</th>
<th>UK</th>
<th>Switzerland</th>
<th>Upper Austria</th>
<th>U.S. NPTS</th>
<th>Santiago</th>
<th>Bogotá</th>
<th>Portland</th>
<th>San Francisco</th>
<th>Japan</th>
<th>Bangkok</th>
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<tbody>
<tr>
<td>Make and model</td>
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<td>No</td>
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<td>Yes</td>
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<td>No</td>
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<td>Yes</td>
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<tr>
<td>VMT per year</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Age</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1 Can be derived
Table 6  Proposed area variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Germany</th>
<th>UK</th>
<th>Switzerland</th>
<th>Upper Austria</th>
<th>U.S. NPTS</th>
<th>Santiago</th>
<th>Bogotá</th>
<th>Portland</th>
<th>San Francisco</th>
<th>Japan</th>
<th>Bangkok</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Yes¹</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Useable area</td>
<td>Yes¹</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Population density</td>
<td>Yes¹</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of work places</td>
<td>Yes¹</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Division of labour force by sectors</td>
<td>Yes¹</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Share of local out- and in-commuting</td>
<td>Yes¹</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Female share of employment</td>
<td>Yes¹</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>GDP (local, regional)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Street density (local, motorway)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes</td>
<td>Yes¹</td>
<td>Yes¹</td>
</tr>
<tr>
<td>Public transport stop density</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes</td>
<td>Yes¹</td>
<td>Yes¹</td>
</tr>
<tr>
<td>Public transport service level</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes²</td>
<td>Yes</td>
<td>Yes¹</td>
<td>Yes¹</td>
</tr>
</tbody>
</table>

¹ Can be estimated
4. Descriptive statistics

5. Methods

*Complex question - methods which can handle relationships between several exogenous and endogenous variables*

5.1 Structural equation modelling (SEM)

A precondition for the analysis of the complex questions posed is a method which can handle relationships between several dependent and independent variables at the same time. SEM meets these requirements (see Maruyama, 1998, Mueller, 1996, Bollen, 1989). SEM is a confirmatory method which should be guided by prior theories about the structures to be modelled. A SEM-model is a set of simultaneous equations specified by direct links between variables which can be latent. A SEM-model without latent variables has only one component - the structural submodel.

The structural submodel captures the relationships between the exogenous and endogenous variables and between the endogenous variables themselves. It is defined by

\[
\eta = B\eta + \Gamma\xi + \zeta
\]

in which the \(m\) endogenous variables are a function of each other and of the \(q\) exogenous variables denoted by \(\xi\). The unexplained portions of the endogenous variables (the errors in equations), have a variance-covariance matrix defined by \(\Psi = E[\xi\xi']\).

The modeller specifies which elements of the \(B\), \(\Gamma\) and \(\Psi\) matrices are free parameters, and these parameters are estimated simultaneously, together with their standard errors. Identification requires, among other conditions, that the matrix \((I - B)\) must be non-singular. The total effects of the exogenous and endogenous variables on the endogenous variables are given by the so-called reduced-form equations:

\[
\eta \rightarrow \eta: \quad (I - B)^{-1} - I
\]
\[ \xi \rightarrow \eta: \quad (I - B)^{-1} \Gamma \]

The estimation of a SEM-model can be accomplished in several ways. The methods are based on matching model-replicated variance-covariances with the observed variance-covariances. Instead of covariances also correlations can be used. Here the Maximum Likelihood-method and the ADF-WLS-method are used in conjunction with a correlation matrix.

5.2 Multi level modelling (MLM)

6. Models

Model suggestions in Figure 1 (see for example Simma, Axhausen, Vrtic, 2001)

Idea:

- Effects between endogenous variables must be estimated
- Effects between exogenous and endogenous variables only if significant
7. Literature

Alves, M.J. and K.W. Axhausen (1994) Activity patterns in three industrialised countries: evidence from recent surveys in the US, the UK and Germany, paper distributed at the 7th International Conference on Travel Behaviour, Chile, July 1994.


Appendix A: Harmonisation of variables

In addition to differences in the survey design most variables are reported and coded differently. To make survey comparisons possible it is necessary to harmonise the variables as far as possible. The harmonisation is connected with a loss of information for each survey, but very important topics, especially the impact of different environments (rural versus urban) can be treated in special models. The following tables give an overview of how the variables should be coded.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbreviation</th>
<th>Unit</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>AGE</td>
<td>n (years)</td>
<td></td>
<td>n</td>
</tr>
<tr>
<td>Sex</td>
<td>SEX</td>
<td></td>
<td>Male</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>1</td>
</tr>
<tr>
<td>Personal income</td>
<td>P_INC</td>
<td>US $</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formal education</td>
<td>EDUC</td>
<td></td>
<td>Up to intermediate</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Highschool</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational training</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>University</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>missing</td>
<td>999</td>
</tr>
<tr>
<td>License holding</td>
<td>LIC_CAR</td>
<td></td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Marital status</td>
<td>MARRIED</td>
<td></td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Personal annual VMT</td>
<td>PVMT</td>
<td>km</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Season ticket ownership</td>
<td>SEASON</td>
<td></td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Car availability</td>
<td>AV_CAR</td>
<td>License holder /cars</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sometimes</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>2</td>
</tr>
<tr>
<td>Car ownership</td>
<td>OW_CAR</td>
<td></td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>2</td>
</tr>
<tr>
<td>Work / school duration (day)</td>
<td>N_O_WH</td>
<td>Min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of jobs</td>
<td>NUM_JOB</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of main job</td>
<td>TYPE_JOB</td>
<td>Character</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work /school location</td>
<td>WSCODE</td>
<td>Character</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nationality / ethnicity</td>
<td>NATION</td>
<td>Character</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8  Specification of person day variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbreviation</th>
<th>Unit</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trips</td>
<td>N_O_T</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of journeys</td>
<td>N_O_J</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum of travel time</td>
<td>D_DIST</td>
<td>min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum of distances</td>
<td></td>
<td>km</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum of out of home activity time</td>
<td>D_OH_DUR</td>
<td>min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum of trip expenditures</td>
<td>D_EXP</td>
<td>US $</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Mode chain: Modes                 | CH_MODE      |           | Walking: 1  
Cycling: 2  
Motorcycles: 3  
Vehicle driver: 4  
Vehicle passenger: 5  
Public transport: 6  
Other: 7  
Missing: 999 |
| Activity chain: Purposes / Activities | CH_PURP  |           | Pick up / drop off: 1  
Private business: 2  
Work related business: 3  
School / Education: 4  
Work: 5  
Shopping: daily: 6  
Shopping: long term: 7  
Leisure: 8  
Other: 9  
Home / at home: 10  
Missing: 999 |
Table 9  Specification of household variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbreviation</th>
<th>Unit</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of members</td>
<td>N_O_HHM</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of workers</td>
<td>N_O_WOR</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of children (under 6)</td>
<td>N_U_6</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of pupils</td>
<td>N_O_EDU</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household income</td>
<td>HH_INC</td>
<td>US $</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home / work location</td>
<td></td>
<td></td>
<td>CBD</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inner City</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Suburbs</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small city</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rural</td>
<td>4</td>
</tr>
<tr>
<td>Accessibility of local services</td>
<td>A_SERV</td>
<td></td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Number of accessible services</td>
<td>S_SERV</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public transport access</td>
<td>DIST_PT</td>
<td>min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of parking spaces</td>
<td>N_O_PS</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle: VMT per year</td>
<td>VMT</td>
<td>US $</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 10  Specification of area variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbreviation</th>
<th>Unit</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (local, regional)</td>
<td>POP</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usable area</td>
<td>AREA</td>
<td>km²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population density</td>
<td>DE_POP</td>
<td>People / km²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of work places</td>
<td>N_WP</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of industry sector</td>
<td>SH_IND</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of agricultural sector</td>
<td>SH_AGR</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of service sector</td>
<td>SH_SERV</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of out-commuters</td>
<td>SH_OCOM</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of in-commuters</td>
<td>SH_ICOM</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female share of employment</td>
<td>SH_FEM</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPD</td>
<td>GPD</td>
<td>US $</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street density</td>
<td>DE_STR</td>
<td>Low, Medium,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public transport stop density</td>
<td>DE_STOP</td>
<td>Low, Medium,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public transport service level</td>
<td>LOS_PT</td>
<td>Low, Medium,</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The files are available at different investigation levels, but connections between the files exist (see Table 11) so that they can be transferred. The files are connected by different number variables.
Table 11  Specification of numbering

<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbreviation</th>
<th>Type of variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study name</td>
<td>STUDY</td>
<td>Character variable</td>
</tr>
<tr>
<td>Study code</td>
<td>STUDCODE</td>
<td>Character variable</td>
</tr>
<tr>
<td>Country of survey</td>
<td>COUN</td>
<td>Character variable</td>
</tr>
<tr>
<td>Code of country</td>
<td>COUNCODE</td>
<td>Character variable</td>
</tr>
<tr>
<td>Location of household</td>
<td>MUNICIP</td>
<td>Character variable</td>
</tr>
<tr>
<td>Municipality number</td>
<td>MUNICODE</td>
<td>Character variable</td>
</tr>
<tr>
<td>Household number</td>
<td>HH_NR</td>
<td></td>
</tr>
<tr>
<td>Person number</td>
<td>PP_NR</td>
<td></td>
</tr>
<tr>
<td>Vehicle number</td>
<td>V_NR</td>
<td></td>
</tr>
</tbody>
</table>

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CH - 8093 Zürich

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Telefax: +41 (0)1 633 10 57
E-Mail: hotz@ivt.baug.ethz.ch
WWW: www.ivt.baug.ethz.ch

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