Any Given Monday
An exploration of the stability of long term activity patterns

Steven Farber – McMaster University
Antonio Páez – McMaster University
Kay Axhausen – ETH Zurich
Analysis of transportation systems has adopted more ideas from the activity paradigm.

We now recognize that travel is a derived demand from participating in activities.

Activity analysis is based on extended forms of travel surveys.
Activity / Travel diaries are typically 1 or 2-days long in the time dimension.

How constant are activities? How much variability in behaviour is there over extended periods of time?

With newer data collection exercises, it now becomes possible to study activity behaviour over longer periods of time.
Objectives:

- Do we have any concept of how well the surveyed day represents the respondents’ usual routine?

- Is a surveyed Monday just like any other Monday? Is it just like any other Weekday?

- Determine if a 1-day sample is representative of a respondent’s typical travel behaviour for that day? For any weekday?
Data

- 230 respondents
- 99 households
- 6 weeks per respondent
- 36761 Episodes
- 8462 person-days

- Frauenfeld City in Canton Thurgau, and Seerucken area to the north
**Challenge**
- How do we quantify between-day similarities in observed behaviour?

- Potential Solution: Multi-level models is a natural way of finding similarities between days. This would require information about days.

**Solution**
- Identify “similar” observations and check for correlation
- Model behaviour as a function of personal characteristics
- Model the residual correlation
Methodology

- The contiguity matrix as an exploratory and analytical tool

- $W(i,j) = 1$ if observation $i$ and $j$ are related

1. **Person** – If observation $i$ and $j$ are the same respondent

2. **PersonDay** – If observation $i$ and $j$ are the same respondent and same day of week

3. **PersonWeek** – If observation $i$ and $j$ are the same respondent and same week

4. **PersonWeekday** – If observation $i$ and $j$ are the same respondent and both Mon-Fri

5. **PersonWeekend** – If observation $i$ and $j$ are the same respondent and both Sat-Sun
What does the W matrix look like?
What does the W matrix look like?
Exploration

- If $W$ matrix is row-standardized, i.e., every row sums to 1, then $Wy$ is a vector of neighbourhood averages around each observation.

- The observed values, $y$, can be plotted against $Wy$ and examined for correlation.
  - Anselin Moran Scatterplot

- Let $Y$ be daily distance travelled – a summary measure of personal mobility.
y vs Wy using the PersonDay Matrix
Moran Scatterplot with Least Square Fit

Moran’s I = Slope = 0.35
Moran’s I Coefficients for Raw Data

\[
I = \frac{\text{correlated variance}}{\text{total variance}} = \frac{Y_s' W Y_s}{Y_s' Y_s}
\]

<table>
<thead>
<tr>
<th>Type</th>
<th>Moran’s I (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person</td>
<td>0.25</td>
</tr>
<tr>
<td>PersonDay</td>
<td>0.35</td>
</tr>
<tr>
<td>PersonWeek</td>
<td>0.26</td>
</tr>
<tr>
<td>PersonWeekday</td>
<td>0.19</td>
</tr>
<tr>
<td>PersonWeekend</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Day on Day correlations stronger than Type of Day correlations

\( \Rightarrow \) a Monday IS a Monday more than just a weekday

A weekend observation is almost uncorrelated to other weekend observations
Model Variables

- Daily Distance Travelled
  - Summary measure of overall mobility
- Demographic
  - Frauenfeld or Seerucken
  - Age
  - Gender
  - Partner
  - Employment Status
  - Income Class
  - Household Composition
  - Housing Tenure
Model Variables

- Activity/Transportation Behaviour
  - Work-Hours
  - Motor Vehicles At Home
  - Average Daily Trips: Mode Choice
    - Public Transport
    - Motorized Individual
    - Non-Motorized
  - Average Daily Trips: Purpose
    - For Business
    - Personal Business
    - For Leisure
Variables

- Walkability of residence
  - Within a 10 minute walk of:
    - kindergarten
    - doctor’s office
    - bank
    - bus stop
    - rail station
    - close friends or relatives
## OLS Regression Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Probability</th>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>13.68</td>
<td>9.57</td>
<td>0.0000</td>
<td>n_o_mv</td>
<td>0.46</td>
<td>3.62</td>
<td>0.0003</td>
</tr>
<tr>
<td>Seerucken</td>
<td>1.57</td>
<td>4.56</td>
<td>0.0000</td>
<td>t_ratnoev</td>
<td>2.11</td>
<td>5.91</td>
<td>0.0000</td>
</tr>
<tr>
<td>age</td>
<td>0.06</td>
<td>3.81</td>
<td>0.0001</td>
<td>t_ratmiv</td>
<td>-2.44</td>
<td>-12.26</td>
<td>0.0000</td>
</tr>
<tr>
<td>Under19</td>
<td>-3.38</td>
<td>-4.52</td>
<td>0.0000</td>
<td>t_ratlv</td>
<td>-3.25</td>
<td>-16.60</td>
<td>0.0000</td>
</tr>
<tr>
<td>Over65</td>
<td>-1.79</td>
<td>-2.34</td>
<td>0.0195</td>
<td>t_ratson</td>
<td>-4.06</td>
<td>-6.68</td>
<td>0.0000</td>
</tr>
<tr>
<td>partner</td>
<td>-1.38</td>
<td>-2.72</td>
<td>0.0066</td>
<td>rat_gesc</td>
<td>2.82</td>
<td>6.52</td>
<td>0.0000</td>
</tr>
<tr>
<td>EmpFull</td>
<td>1.35</td>
<td>2.26</td>
<td>0.0238</td>
<td>rat_frei</td>
<td>2.45</td>
<td>6.35</td>
<td>0.0000</td>
</tr>
<tr>
<td>EmpPart</td>
<td>1.25</td>
<td>2.44</td>
<td>0.0147</td>
<td>rat_erle</td>
<td>2.23</td>
<td>2.77</td>
<td>0.0056</td>
</tr>
<tr>
<td>n_o_wh</td>
<td>0.07</td>
<td>5.39</td>
<td>0.0000</td>
<td>walk_kin</td>
<td>-1.19</td>
<td>-2.93</td>
<td>0.0034</td>
</tr>
<tr>
<td>INC1</td>
<td>-6.70</td>
<td>-3.31</td>
<td>0.0009</td>
<td>walk_doc</td>
<td>1.56</td>
<td>3.75</td>
<td>0.0002</td>
</tr>
<tr>
<td>INC2</td>
<td>-5.84</td>
<td>-5.65</td>
<td>0.0000</td>
<td>walk_ban</td>
<td>-2.02</td>
<td>-5.15</td>
<td>0.0000</td>
</tr>
<tr>
<td>INC3</td>
<td>-4.24</td>
<td>-4.50</td>
<td>0.0000</td>
<td>walk_bus</td>
<td>2.05</td>
<td>4.46</td>
<td>0.0000</td>
</tr>
<tr>
<td>INC4</td>
<td>-6.30</td>
<td>-7.77</td>
<td>0.0000</td>
<td>walk_rai</td>
<td>2.85</td>
<td>6.96</td>
<td>0.0000</td>
</tr>
<tr>
<td>INC5</td>
<td>-2.34</td>
<td>-5.41</td>
<td>0.0000</td>
<td>walk_rel</td>
<td>-1.05</td>
<td>-3.29</td>
<td>0.0010</td>
</tr>
<tr>
<td>INC6</td>
<td>0.45</td>
<td>1.24</td>
<td>0.2156</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n_o_hha</td>
<td>-1.99</td>
<td>-7.02</td>
<td>0.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n_o_hh6</td>
<td>-4.89</td>
<td>-3.05</td>
<td>0.0023</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n_o_hh12</td>
<td>0.56</td>
<td>2.04</td>
<td>0.0410</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rented</td>
<td>0.68</td>
<td>1.85</td>
<td>0.0646</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Summary Statistics
- $R^2 = 0.1710$
- $\sigma^2 = 140.1282$
- Nobs, Nvars = 8462, 33
Residuals – Moran Scatterplot
Moran’s I coefficients suggest there is an unobserved correlation structure between observations

\[ I = \frac{\text{correlated variance}}{\text{total variance}} = \frac{\varepsilon' W \varepsilon}{\varepsilon' \varepsilon} \]
(Spatial) Model Options

(Spatial) Error Model

\[
Y = X\beta + u \\
\quad u = \lambda Wu + \varepsilon
\]

Implies that we are missing information on observations that are somehow related.
## SEM Results

<table>
<thead>
<tr>
<th>Specification</th>
<th>Log-Likelihood</th>
<th>R-Squared</th>
<th>Sigma-Squared</th>
<th>lambda</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person</td>
<td>-29693</td>
<td>0.23</td>
<td>129.0</td>
<td>0.56</td>
<td>0.9700</td>
</tr>
<tr>
<td>PersonDay</td>
<td>-29654</td>
<td>0.25</td>
<td>126.0</td>
<td>0.32</td>
<td>0.0000</td>
</tr>
<tr>
<td>PersonWeek</td>
<td>-29847</td>
<td>0.20</td>
<td>134.0</td>
<td>0.23</td>
<td>0.0000</td>
</tr>
<tr>
<td>PersonWeekday</td>
<td>-29746</td>
<td>0.22</td>
<td>130.7</td>
<td>0.54</td>
<td>0.0000</td>
</tr>
<tr>
<td>PersonWeekEnd</td>
<td>-29945</td>
<td>0.18</td>
<td>138.5</td>
<td>0.25</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

1. Improved model fit indicated by R-Square increase and reduction in variance of the estimates
2. Insignificant Person on Person error autocorrelation, individual characteristics are well-described by covariates in the model
3. Weekday and Weekend correlation is much stronger than previously indicated
Future Work

- Decomposition of the correlation coefficients into LISA statistics to explore the factors that cause some people to have more consistent activity patterns compared to others
  - Are some people typically atypical?

- Extend the analysis to other summary measures such as coded DAP’s or durations of different activity types

- Convert findings into an improved understanding of behavioural patterns. Would be nice to know how many days are necessary to capture “weekday”, a “weekend day”, a “Tuesday” etc
Questions?