Any Given Monday

An exploration of the stability of long term activity patterns

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Background

- 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

Background

- 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

Methodology

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

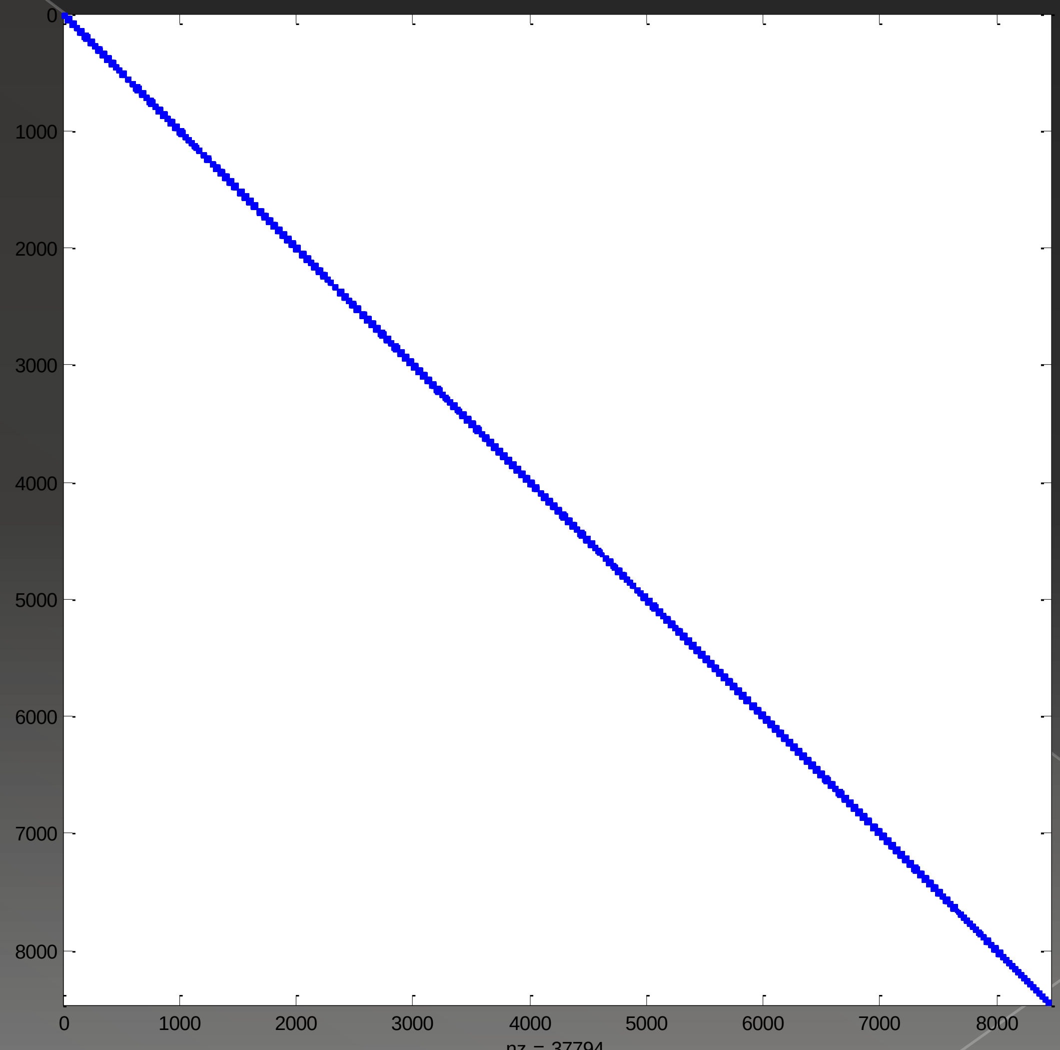
Methodology

- 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?



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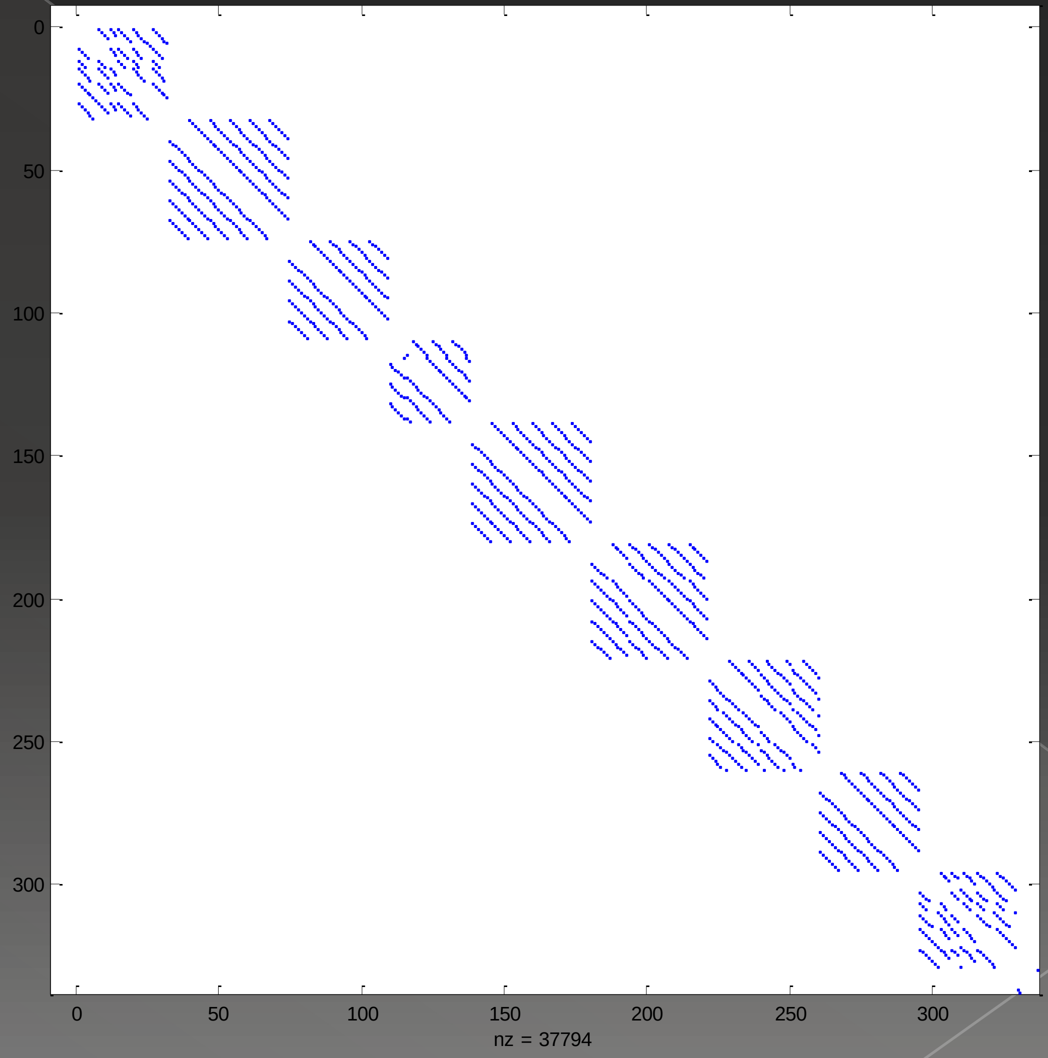
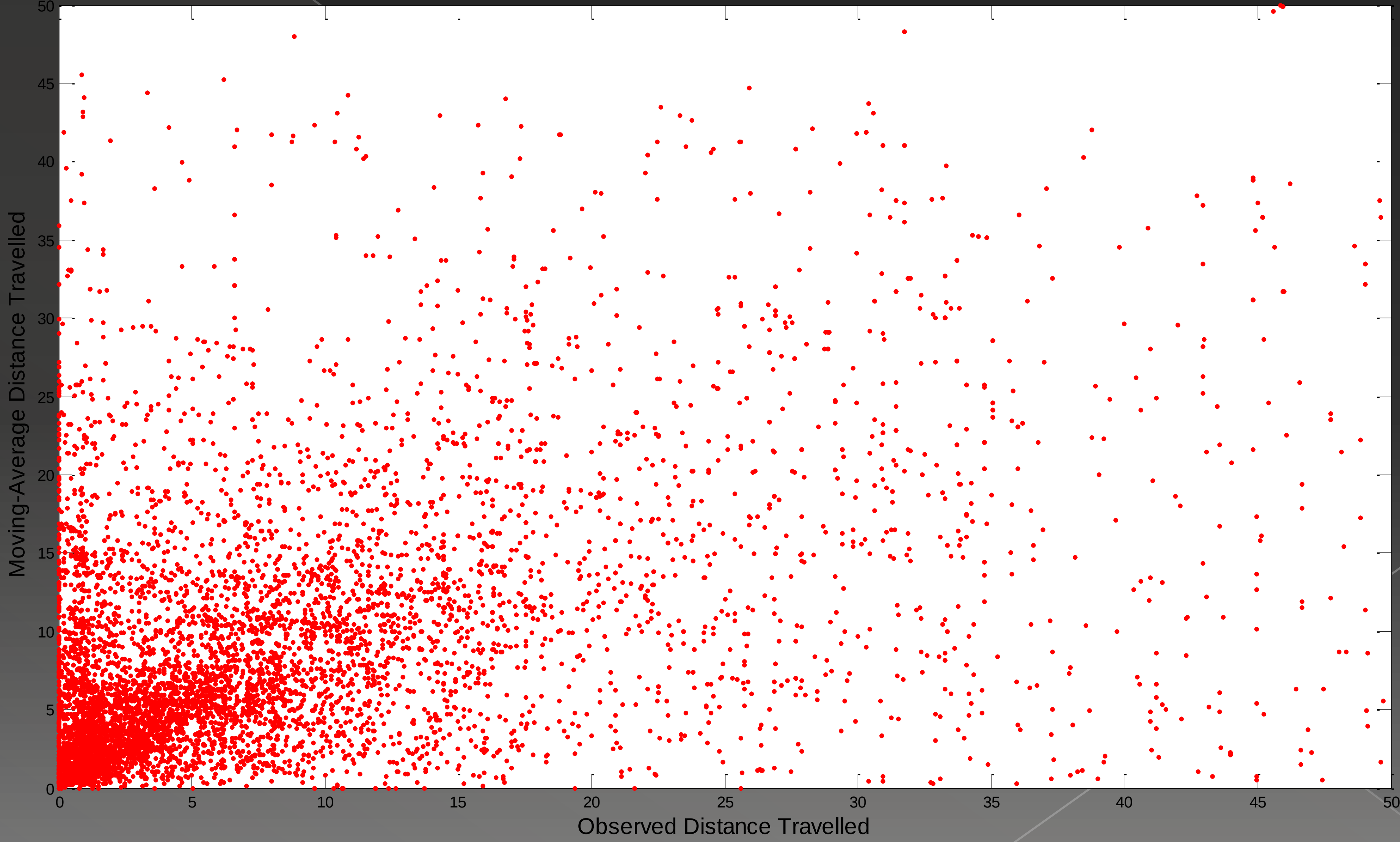


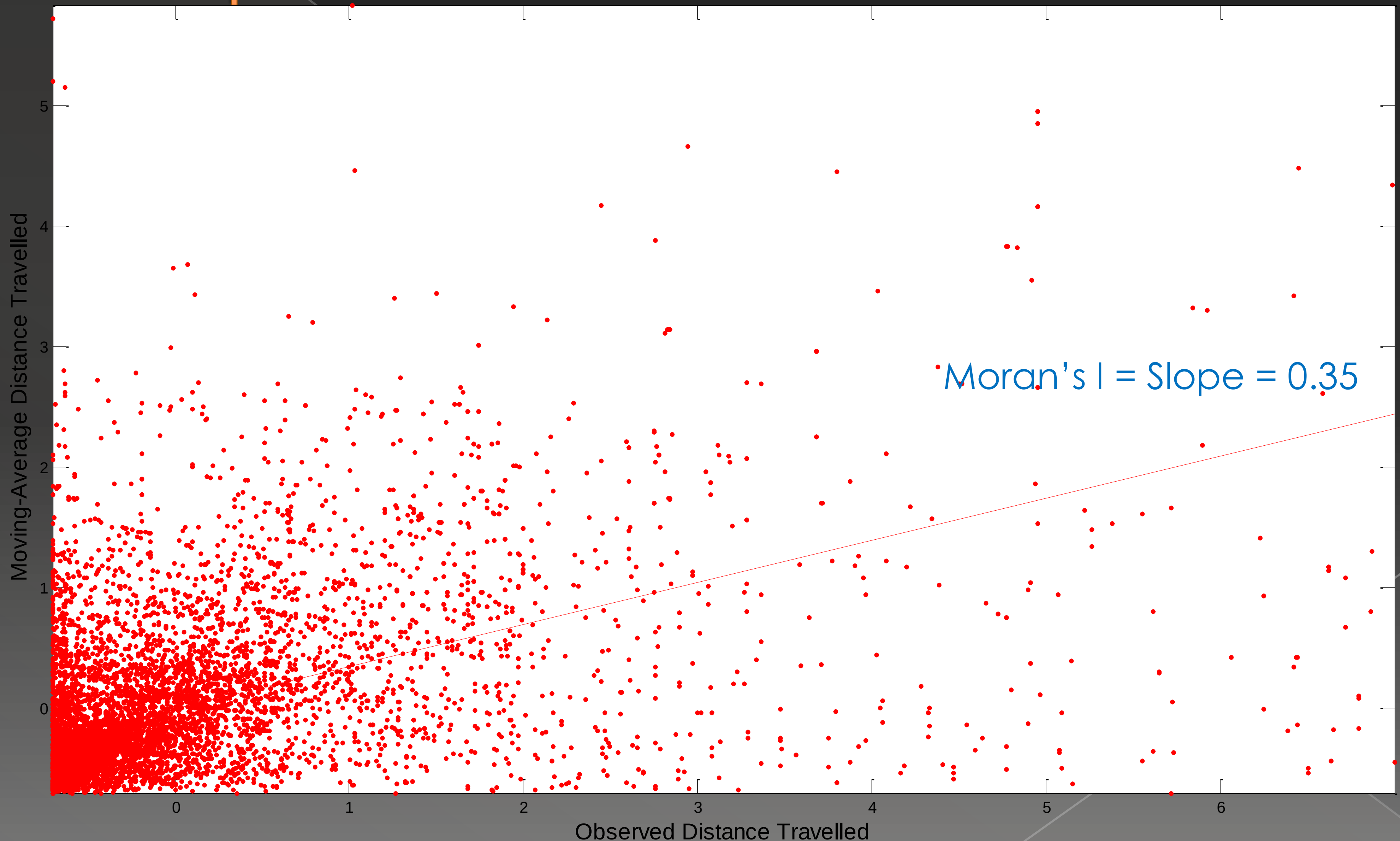
Exploration

- If W matrix is row-standardized, ie: 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 Coefficients for Raw Data

$$I = \frac{\text{correlated variance}}{\text{total variance}} = \frac{Y_s^{'} W Y_s}{Y_s^{'} Y_s}$$

Person	0.25
PersonDay	0.35
PersonWeek	0.26
PersonWeekday	0.19
PersonWeekend	0.07

Day on Day correlations stronger than Type of Day correlations
→ 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

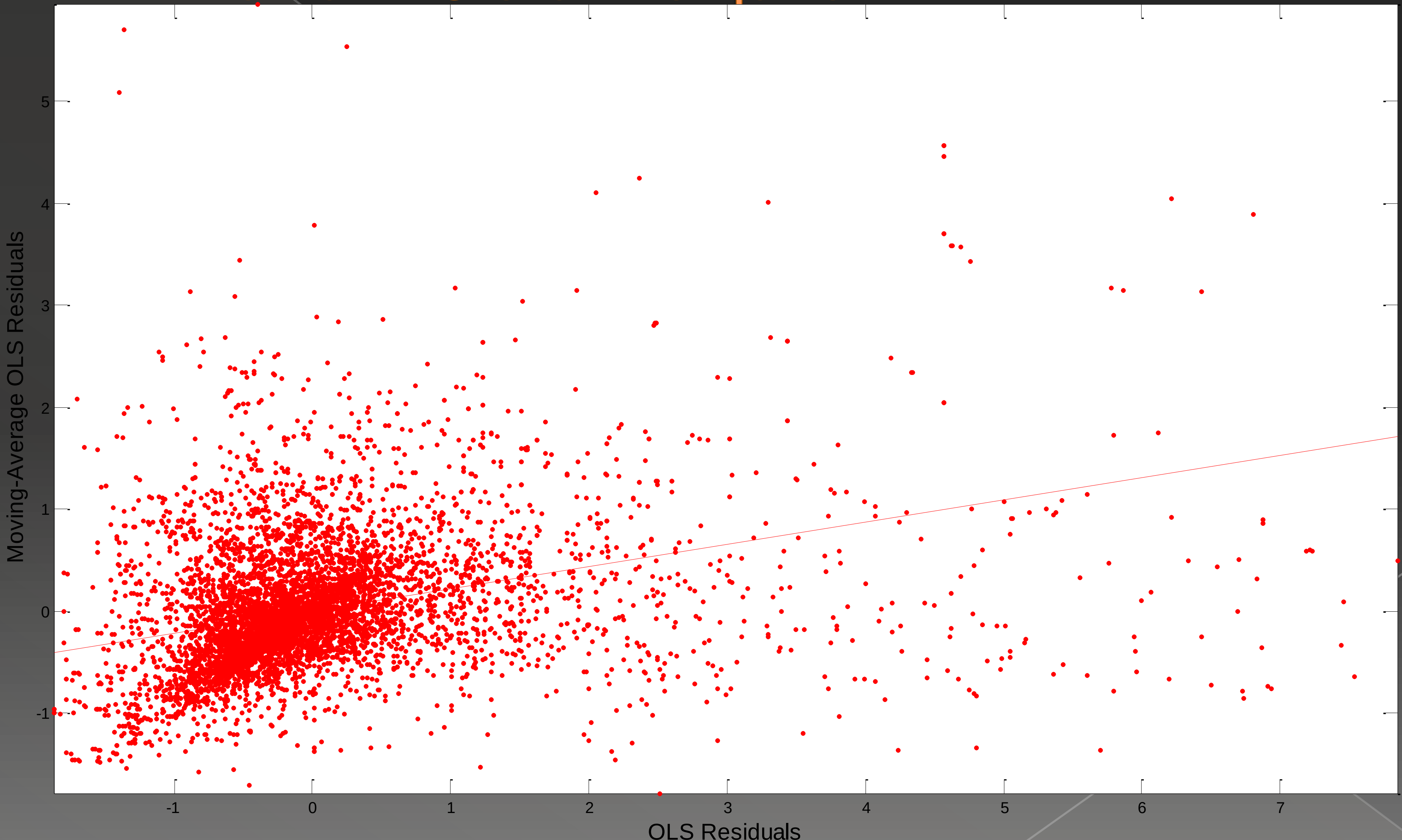
Variables

- 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

Variable	Coefficient	t-statistic	Probability	Variable	Coefficient	t-statistic	Probability
Constant	13.68	9.57	0.0000	n_o_mv	0.46	3.62	0.0003
Seerucken	1.57	4.56	0.0000	t_ratoev	2.11	5.91	0.0000
age	0.06	3.81	0.0001	t_ratmiv	-2.44	-12.26	0.0000
Under19	-3.38	-4.52	0.0000	t_ratlv	-3.25	-16.60	0.0000
Over65	-1.79	-2.34	0.0195	t_ratson	-4.06	-6.68	0.0000
partner	-1.38	-2.72	0.0066	rat_gesc	2.82	6.52	0.0000
EmpFull	1.35	2.26	0.0238	rat_frei	2.45	6.35	0.0000
EmpPart	1.25	2.44	0.0147	rat_erle	2.23	2.77	0.0056
n_o_wh	0.07	5.39	0.0000	walk_kin	-1.19	-2.93	0.0034
INC1	-6.70	-3.31	0.0009	walk_doc	1.56	3.75	0.0002
INC2	-5.84	-5.65	0.0000	walk_ban	-2.02	-5.15	0.0000
INC3	-4.24	-4.50	0.0000	walk_bus	2.05	4.46	0.0000
INC4	-6.30	-7.77	0.0000	walk_rai	2.85	6.96	0.0000
INC5	-2.34	-5.41	0.0000	walk_rel	-1.05	-3.29	0.0010
INC6	0.45	1.24	0.2156				
n_o_hha	-1.99	-7.02	0.0000			Summary Statistics	
n_o_hh6	-4.89	-3.05	0.0023			R-squared = 0.1710	
n_o_hh12	0.56	2.04	0.0410			sigma^2 = 140.1282	
rented	0.68	1.85	0.0646			Nobs, Nvars = 8462, 33	

Residuals – Moran Scatterplot



Residual Autocorrelation

$$I = \frac{\text{correlated variance}}{\text{total variance}} = \frac{\varepsilon' W \varepsilon}{\varepsilon' \varepsilon}$$

Person	0.10
PersonDay	0.22
PersonWeek	0.12
PersonWeekday	0.09
PersonWeekend	0.04

Moran’s I coefficients suggest there is an unobserved correlation structure between observations

(Spatial) Model Options

(Spatial) Error Model

$$Y = X\beta + u$$

$$u = \lambda W u + \varepsilon$$

Implies that we are missing information
on observations that are somehow related

SEM Results

Specification	Log-Likelihood	R-Squared	Sigma-Squared	lambda	Probability
Person	-29693	0.23	129.0	0.56	0.9700
PersonDay	-29654	0.25	126.0	0.32	0.0000
PersonWeek	-29847	0.20	134.0	0.23	0.0000
PersonWeekday	-29746	0.22	130.7	0.54	0.0000
PersonWeekEnd	-29945	0.18	138.5	0.25	0.0000

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?