Alternatives and Attributes in Route Choice Estimation for Urban Traffic Management Using GPS-data

Anna Danielsson

LINKÖPINGS UNIVERSITET

Agenda

- Introduktion multimodal trafikledning
- Ruttvalsestimering

Multimodal Trafikledning

David Gundlegård, Anna Danielsson, Clas Rydergren, Nikolaos Tsanakas, Matej Cebecauer, Wilco Burghout, Erik Jenelius

Samarbete mellan LiU och KTH

Finansierat av Trafikverket genom CTR

Projektgrupp

Richard Rek

Anna Danielsson

David Gundlegård

Nikolaos Tsanakas

Clas Rydergren

Rasmus Ringdahl

Matej Cebecauer

Wilco Burghout

Erik Jenelius

Anastasios Skoufas

Multimodal Trafikledning (MMTL)

- Fyrstegsprincipen i kombination med urbanisering gör att trafiksystem ofta hanteras på gränsen av sin kapacitet
- Små förändringar i utbud kan få stor effekt på systemets prestanda och stor samhällsekonomisk påverkan
  - Viktigt med bra beslutsunderlag och analysverktyg för ledning och styrning
- Målet på sikt är att kunna utvärdera och följa upp åtgärdsplaner i realtid

Övergripande projektmål

- Bättre förståelse för multimodala resmönster
- Nya metoder för att skatta och prediktera multimodal efterfrågan
- Nya metoder för att prediktera rutt- och färdmedelsval
- Identifiera synergier och utmaningar med multimodal trafikledning

Frågeställningar kopplat till incidenthantering

- Hur kan vi prediktera trafiktillståndet vid incidenter (inklusive effekter från rutt- och färdmedelsval)?
- Vilka trafikströmmar är mest påverkade av incidenten (och påverkar incidenten mest)?
- Vilka multimodala omledningsalternativ är tillgängliga för dessa trafikströmmar?
- Hur påverkar omledningen framtida trafiktillstånd?

Vad innebär multimodal trafikledning?

- Trafikledning
  - Wikipedia (2022): “Guiding travelers to avoid incidents, road work and congestion for traffic safety”
  - Meng et al. (2018): ”Integrated traveller information, as provided by traffic control centres, serves to assist travellers to plan their trips better”
  - Semanjski och Gautama (2018): “Traffic management in urban areas includes management of motorized vehicles, public transport, pedestrians, bicyclists and other flows and aims to provide safe, orderly and efficient movement of persons and goods, as well as *efficient interaction between different transportation modes*”
- Multimodal trafikledning
  - Varierande innebörd i litteraturen
  - Fokus i projektet: integrerad trafikledning för personresor med väg- och kollektivtrafik
  - Intressanta tillägg: gods, icke-motoriserade färdmedel

Översikt av projektets delområden

Explorativ analys av multimodal data

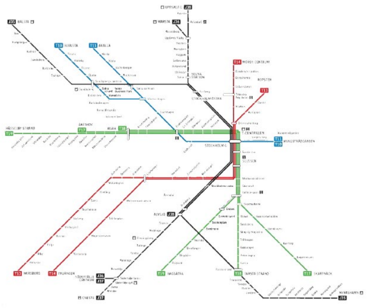
Datadriven rutt- och färdmedelsmodellering

MMTL

Skattning av multimodal efterfrågan

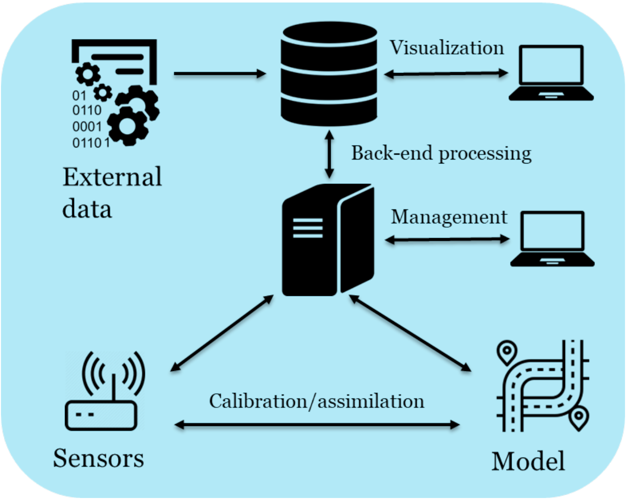
Scenarioutvärdering och analys

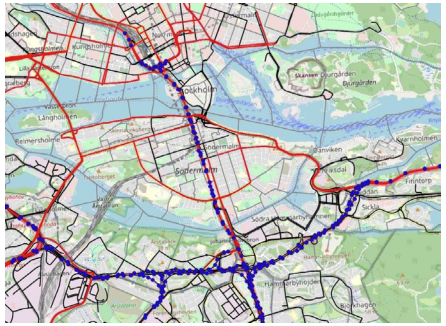
Datakällor



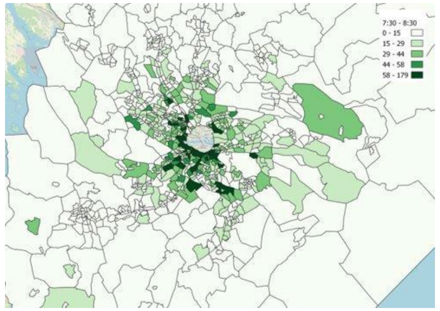
Kollektivtrafikdata

Plattform för trafikdata

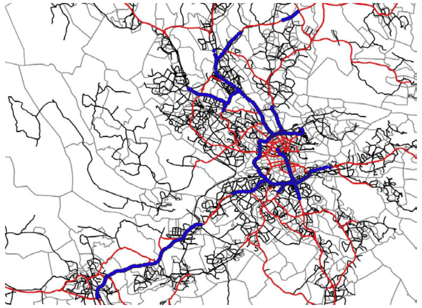




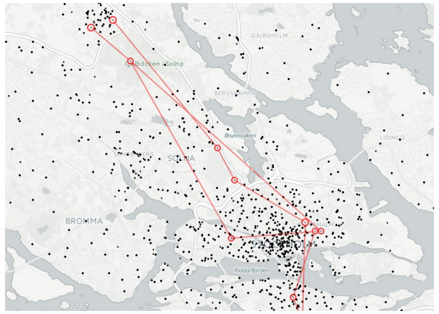
Flödesmätningar



Trängselskatteportaler



GPS-spår (Inrix)



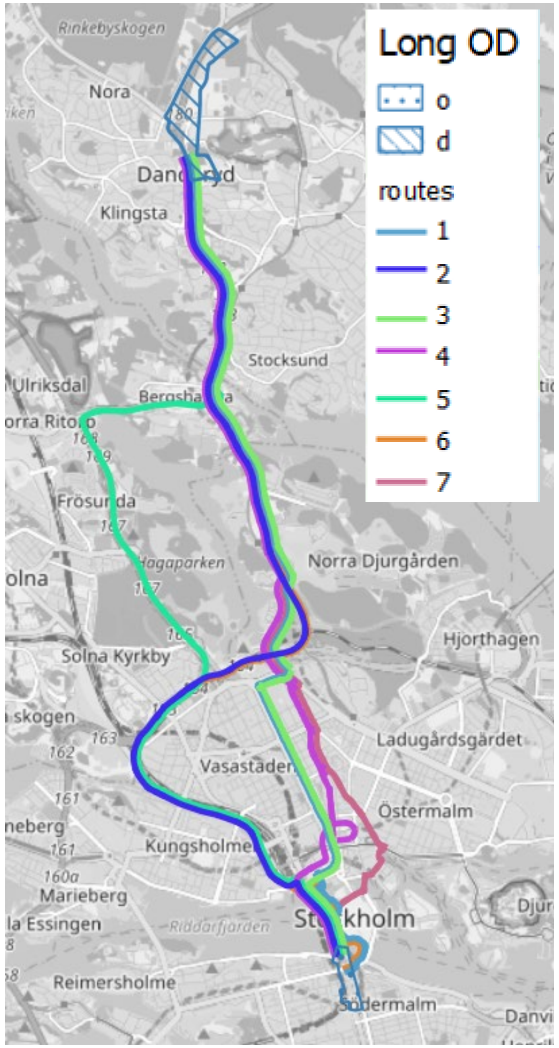
Mobilnätsdata (Telia)

Datadriven ruttvalsmodellering

Datadriven ruttvalsmodellering

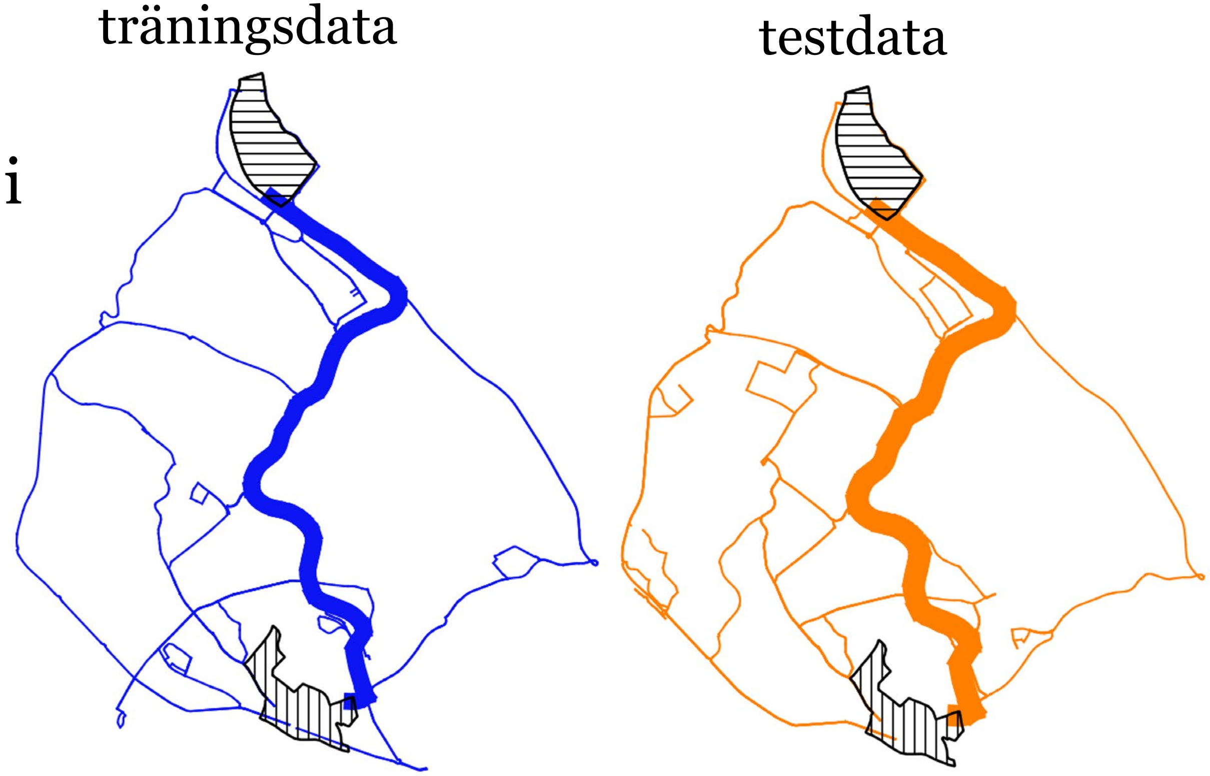
- Ruttval för trafikledning
  - Prediktering trafiktillstånd
  - Skattning av OD
  - Riktad trafikantinformation

- Detaljerad GPS-data används för att estimera en Logit-baserad diskret valmodel
  - Vilka rutter finns att välja på?
  - Vilka attribut påverkar ruttvalet?
    - Restid, reslängd, kapacitet, antal svängar, antal trafikljus…



Ruttset

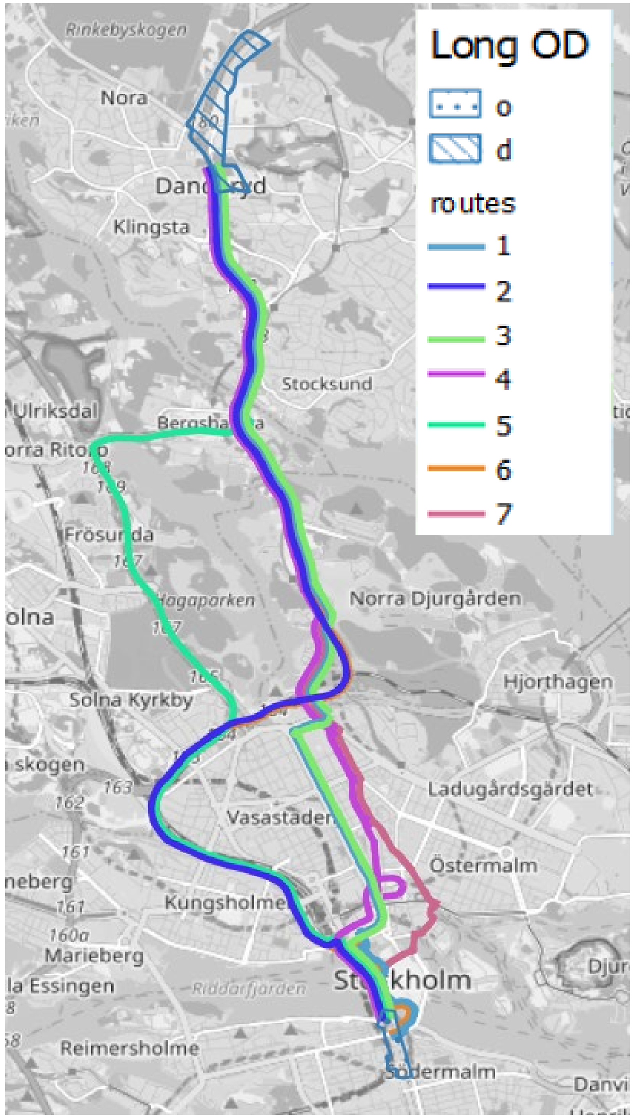
- Ett antal ruttalternativ som varje resenär antas välja mellan definieras i förväg
- 2 metoder för att ta fram dessa ruttset:
  1. Observerade rutter
  2. Observerade + kortaste väg generering
- Rutterna under de första två veckorna jämfördes med de kommande två veckorna



	Attribute	Explanation
Traveltime	tt_mean	Mean traveltime for the route in minutes, averaged over four time periods over the day.
	tt_free	Free flow traveltime in minutes, calculated as $\frac{length}{speed\ limit}$.
	dummy_tt	1 if the traveltime is more than 50 % longer than the traveltime of the shortest path in the OD-pair, 0 otherwise.
Length	r_length	Route length in meters.
	dummy_length	1 if the route length is more than 50 % longer than the shortest path in the OD-pair, 0 otherwise.
Delay, variance	delay	Relative difference between mean traveltime and free flow traveltime, calculated as $\frac{tt\_mean - tt\_free}{tt\_free}$.
	tt_var_route	Traveltime variance of the route over the four time periods. The attribute shows how much the route traveltime varies over the day.
	tt_var_sum	Sum of the link traveltime variance in the route over the four time periods. Thus, the attribute is a summation of how much the traveltime of the links in the route varies over the day.
Simplicity	p_major_roads	Percentage of links with low road class (highways and other major roads).
	congestion_charge	Cost in SEK from congestion charging based on starting time.
	left_turns	Number of turns with an angle of $70 \leq \alpha \leq 170$ degrees.
	num_links	Number of links in the route, as a proxy for number of intersections.
	PS	Path size factor accounting for similar alternatives

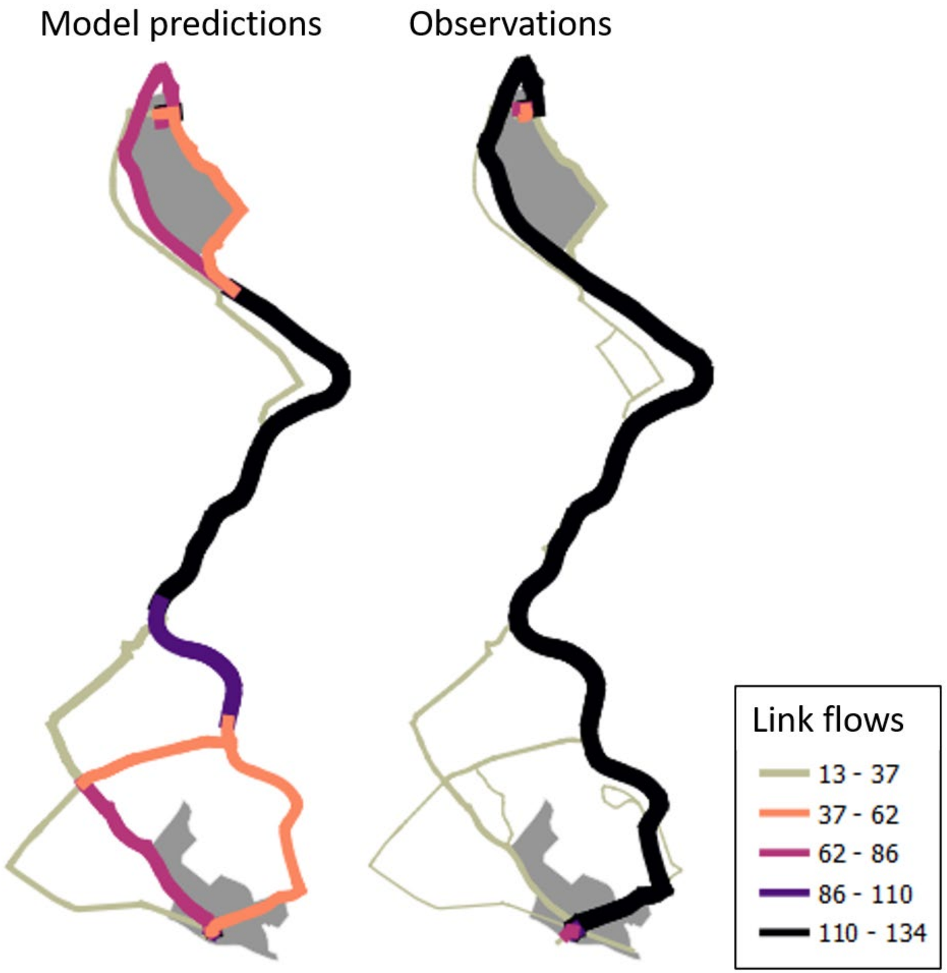
Modelestimering

- Attributen viktas mot varandra i en logitmodell med hjälp av maximum likelihood estimering
- I modellen får varje resenär en sannolikhet att respektive rutt väljs
  1. 8 %
  2. 45 %
  3. 20%
  4. 2 %
  5. 20 %
  6. 2 %
  7. 3 %
- Den aggregerade sannolikheten för respektive rutt jämförs med observerad fördelning



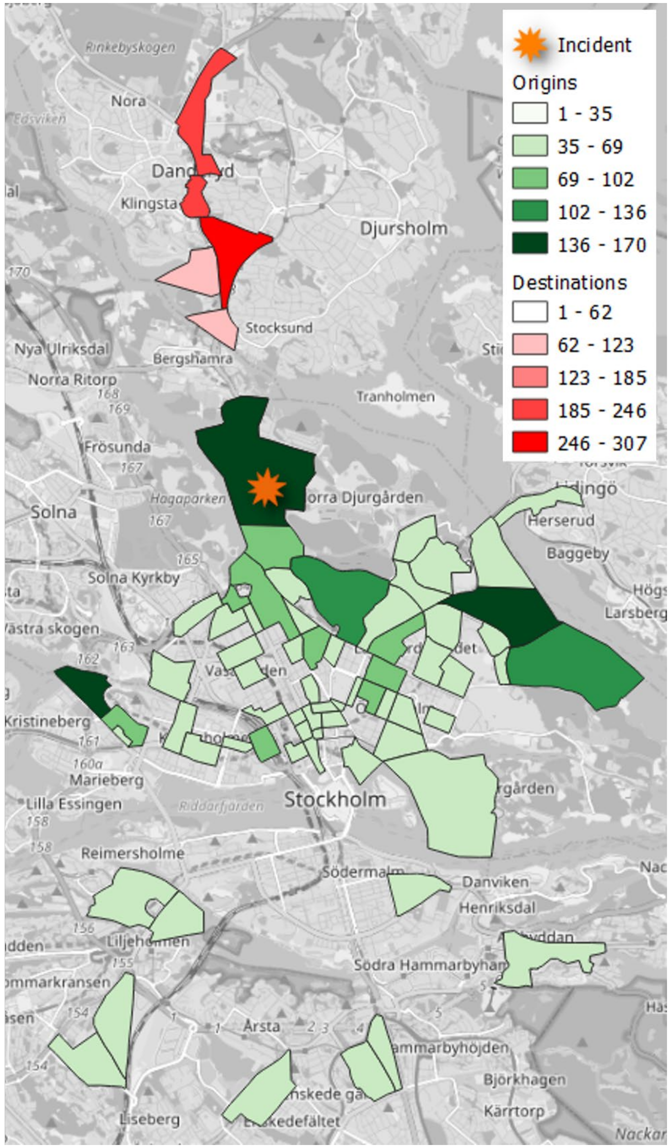
Resultat

- Viktiga attribut för ruttvalet är
  - Enkelhet (andel på större vägar och antal korsningar)
  - Medelrestid
  - Reslängd
- Modellen är mer känslig för restid när ruttsetet utökats med genererade rutter.
- En modell med bara restid som förklaringsvariabel fångar inte upp alla aspekter av ruttvalet.



Slutsatser

- Datasetet verkar lovande för den här typen av analyser.
- En bra ruttvalsmodell kan ge viktiga insikter för trafikledning.
  - Prediktering trafiktillstånd
  - Skattning av OD
  - Riktad trafikantinformation
- Med en modell som är känslig för restidsförändringar kan ruttval under incidenter predikteras.



Multimodal day-types

Matej Cebecauer

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Multimodal day-types

Day-types:

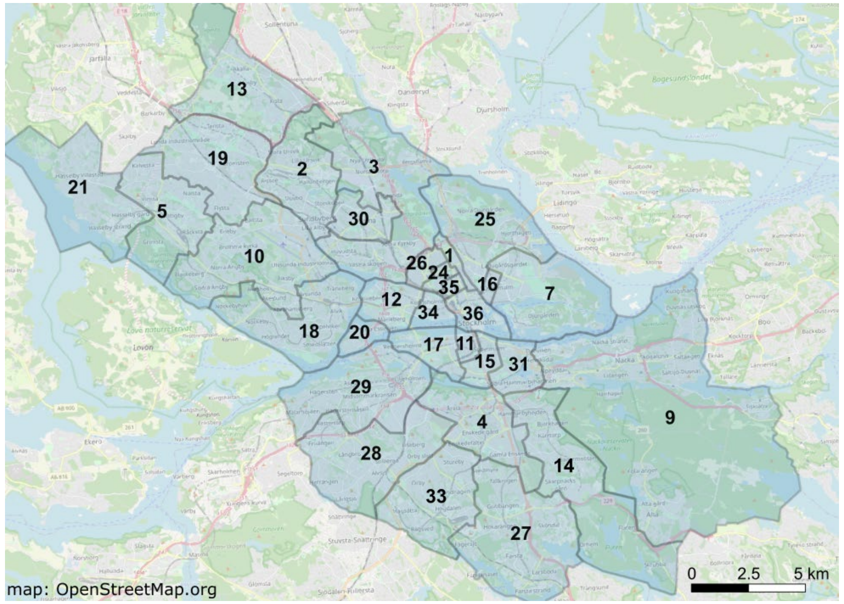
– Representative typical days

How we reveal representative day-types:

1. Clustering
   - groups the days based on their similarities, such
     – Minimize the variance/distance/dissimilarity among days in each cluster
     – Maximize the variance/distance/dissimilarity to days in other clusters
2. Representative of the cluster is the recognized day-type
   – Could be an average day of the cluster

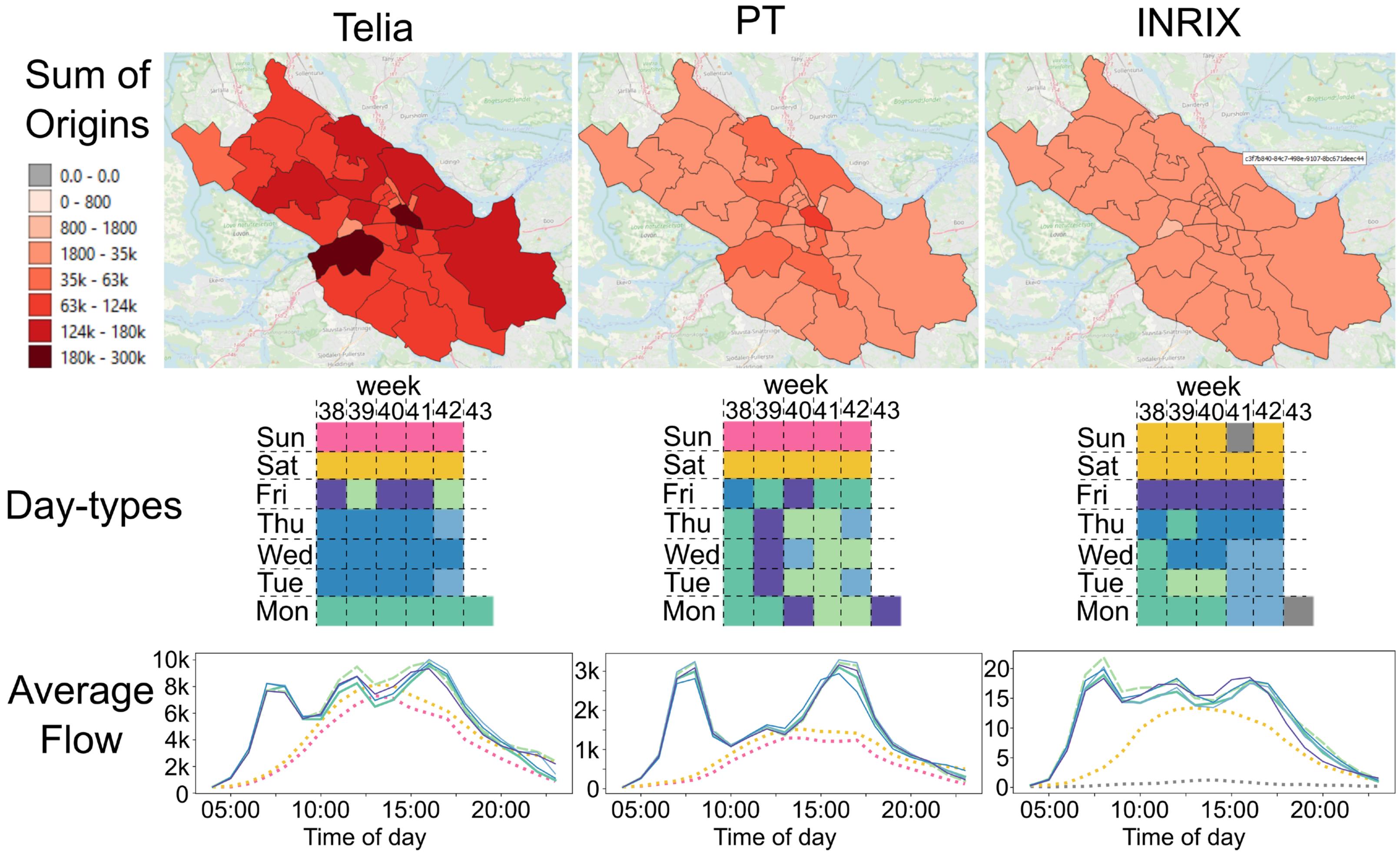
Multimodal day-types

- Telia mobile data (Total demand)
- Public transport smart card data (PT demand)
- INRIX data
- PT mode share



- 31 – zones (961 OD pairs)
- 2019 (week 38–42)
- Dynamic OD matrices
- 1 hour time intervals (04:00 – 23:00)

Multimodal day-types



PT mode share estimation and analysis

Why of interest?

- Traditionally based on travel surveys
  - continuous decline in respondent rates over the past decades
    - 68% (from 25,000 interviews) in 2005
    - 28% (from 12,500) in 2021.
  - concerns if samples are truly representative of the general population
  - very costly to estimate PT shares over long time periods with high temporal resolution
  - respondent background information and formulate questions

source: Travel Surveys, Trafik Analysis, https://www.trafa.se/en/travel-survey/travel-survey/

PT mode share estimation and analysis

Why of interest?

– Data-driven approach

Telia data

- Represent TOTAL flow
  - private cars, walking, cycling, PT, micromobility, etc.
- Historical days and high temporal resolution

Smart card data

- Represent almost TOTAL PT flow
  - Impact of inference rate, missing validations
- Historical days and high temporal resolution

- Cost-effective technology for spatio-temporal estimation of PT mode share
  - Data already being collected
  - High spatio-temporal resolution available
- Observation-based, anonymized, no additional questions

PT mode share analysis

Descriptive and cluster analysis

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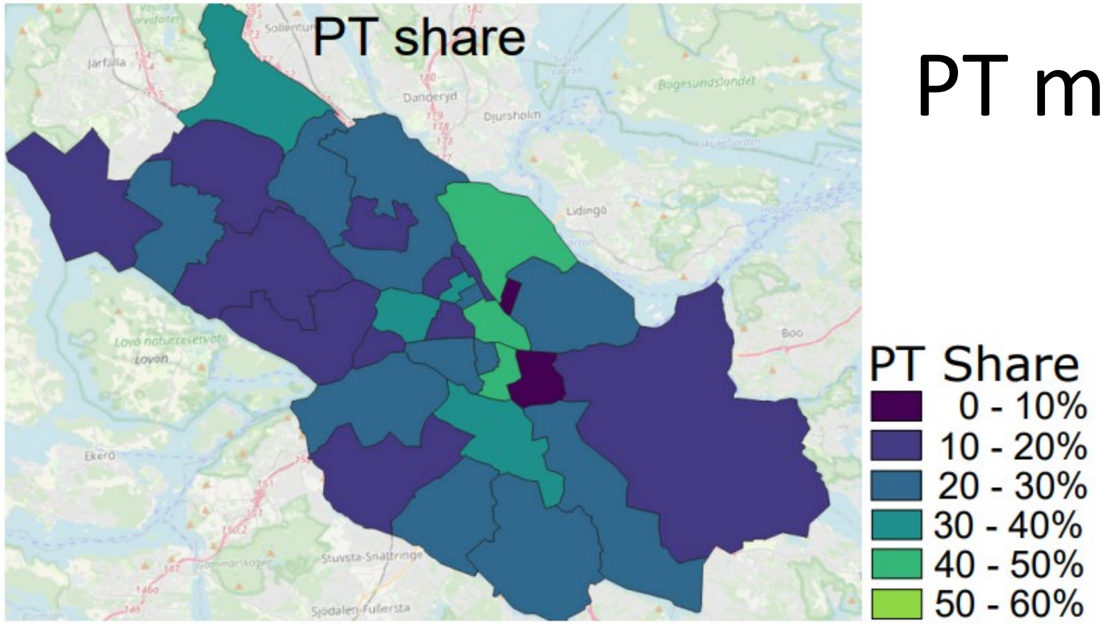
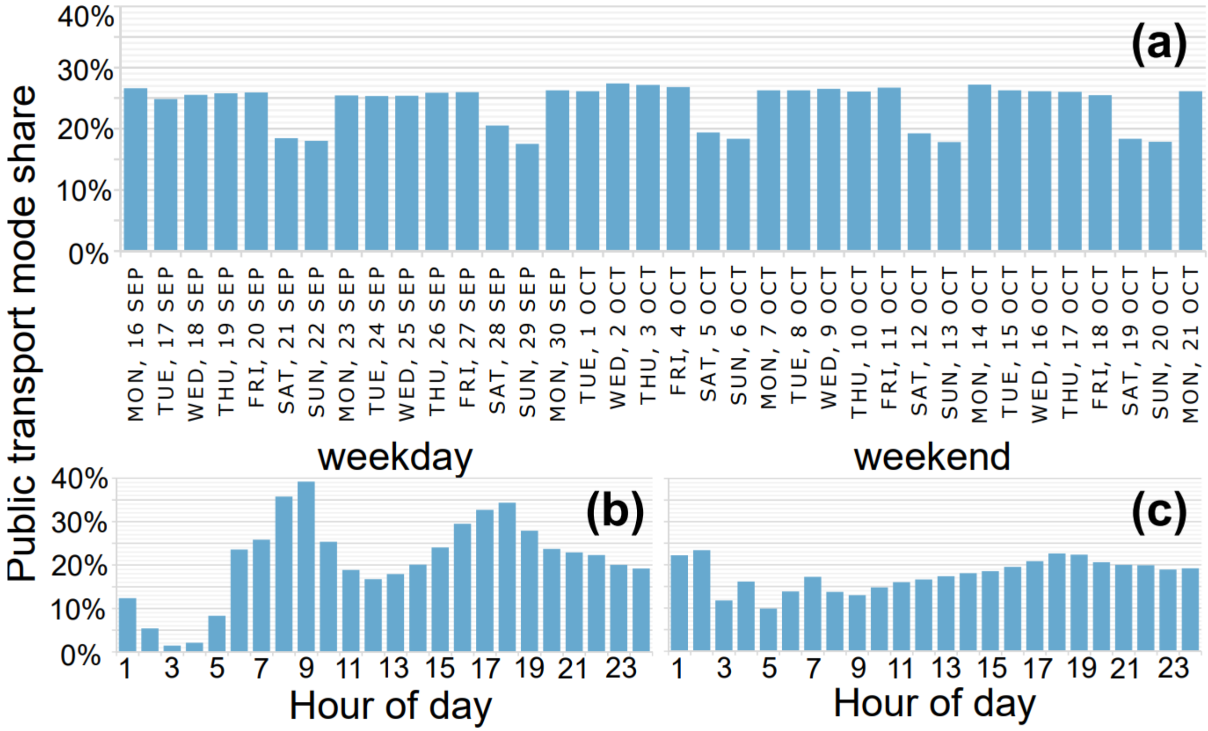
PT mode share analysis





$$PTshare = \frac{PT}{Telia}$$

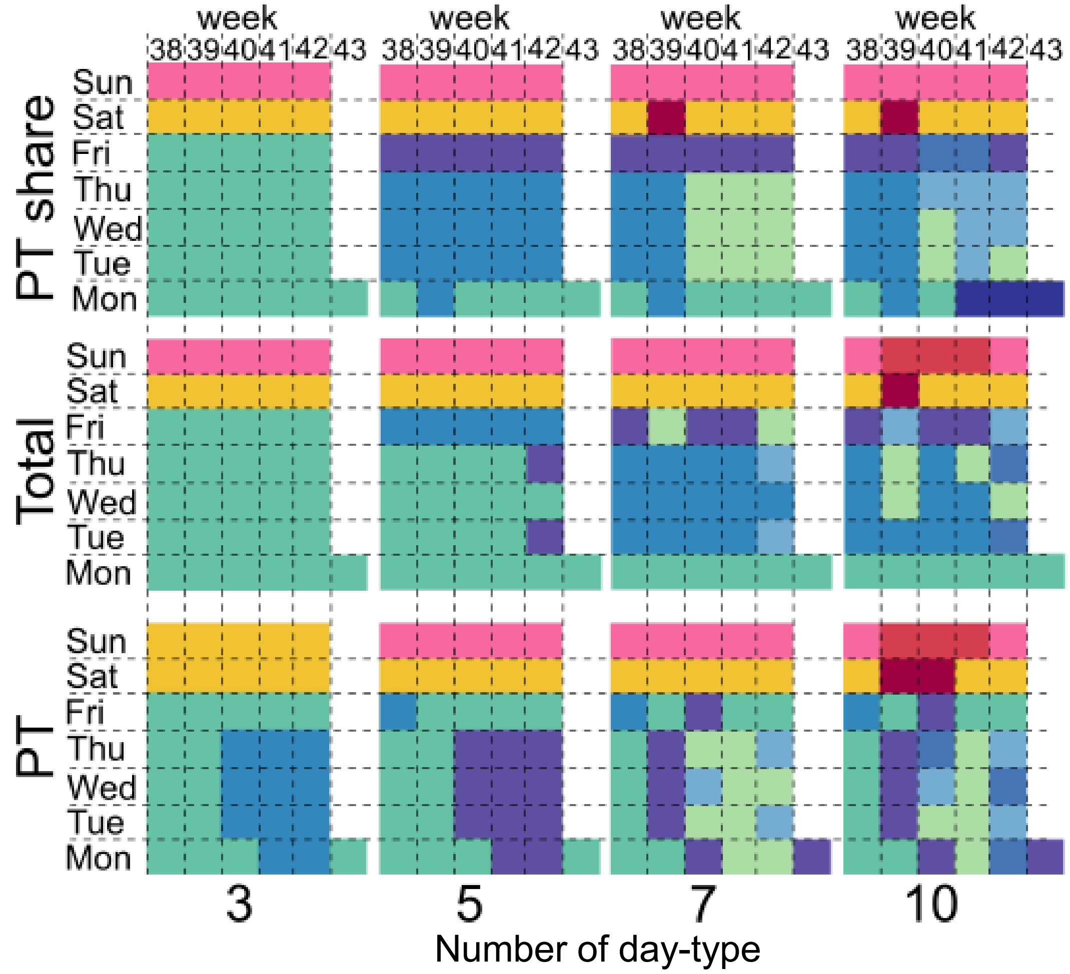
Data-driven estimation

- ~85% of demand captured
- Limited to journeys within case-study zones

Region Stockholm Travel survey, 2019

- All journeys within region
- 30% of all journeys are made by PT
- Regional centers
  - Sundbyberg 32%
  - Solna 40%
  - Stockholm inner city 36%
    - 70% of motorized trips

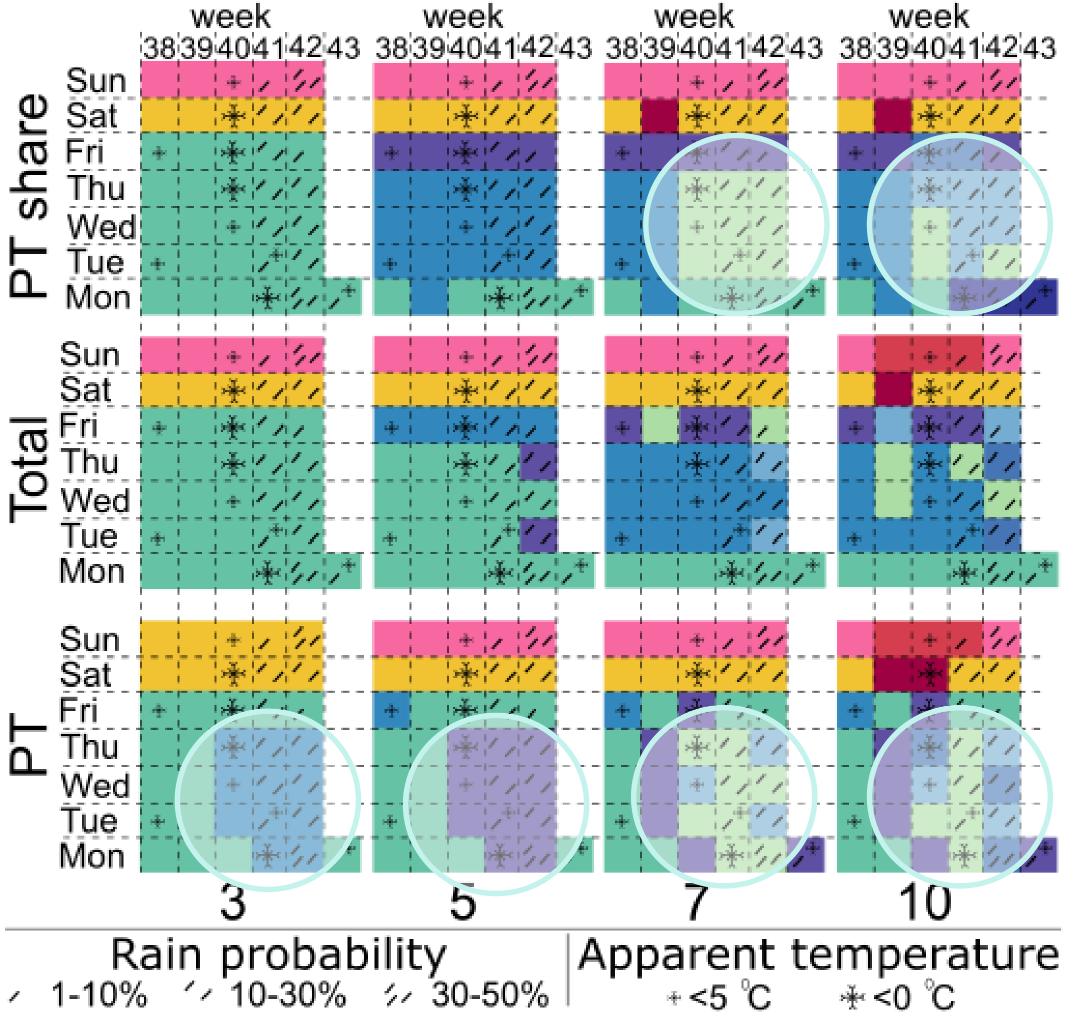
PT mode share analysis



Evolution of representative day-type patterns

1. Weekdays and weekends
2. Saturdays and Sundays
3. Fridays
4. Mondays
5. Using contextual information

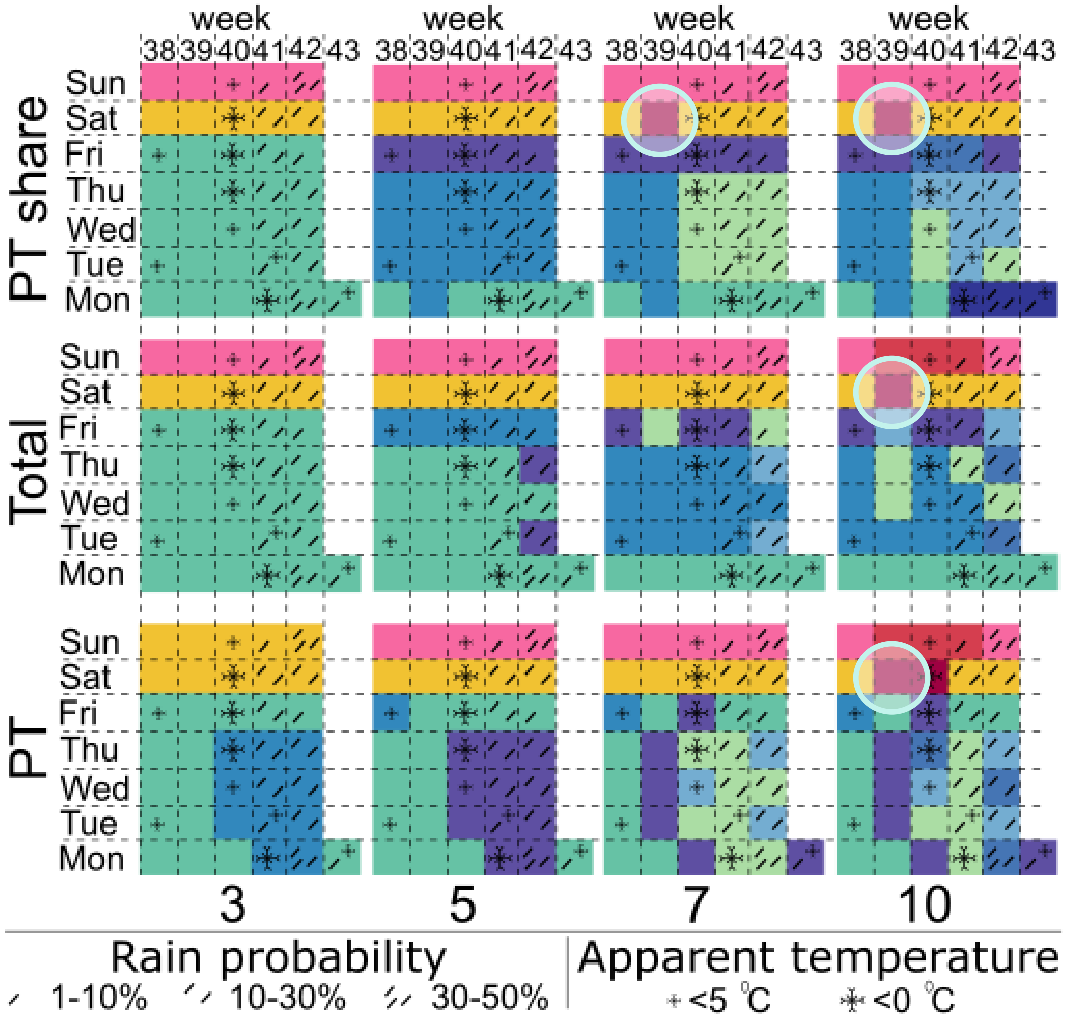
PT mode share analysis



Evolution of representative day-type patterns

1. Weekdays and weekends
2. Saturdays and Sundays
3. Fridays
4. Mondays
5. Using contextual information
   - Impact of weather on PT
     - More rainy and cold weather
     - Does it attract traveler to PT?

PT mode share analysis



Evolution of representative day-type patterns

1. Weekdays and weekends
2. Saturdays and Sundays
3. Fridays
4. Mondays
5. Using contextual information
   - Impact of weather on PT
     - More rainy and cold weather
   - Special events
     - 28th of September - large memorial ceremony related to the passenger ferry M/S Estonia ship disaster.

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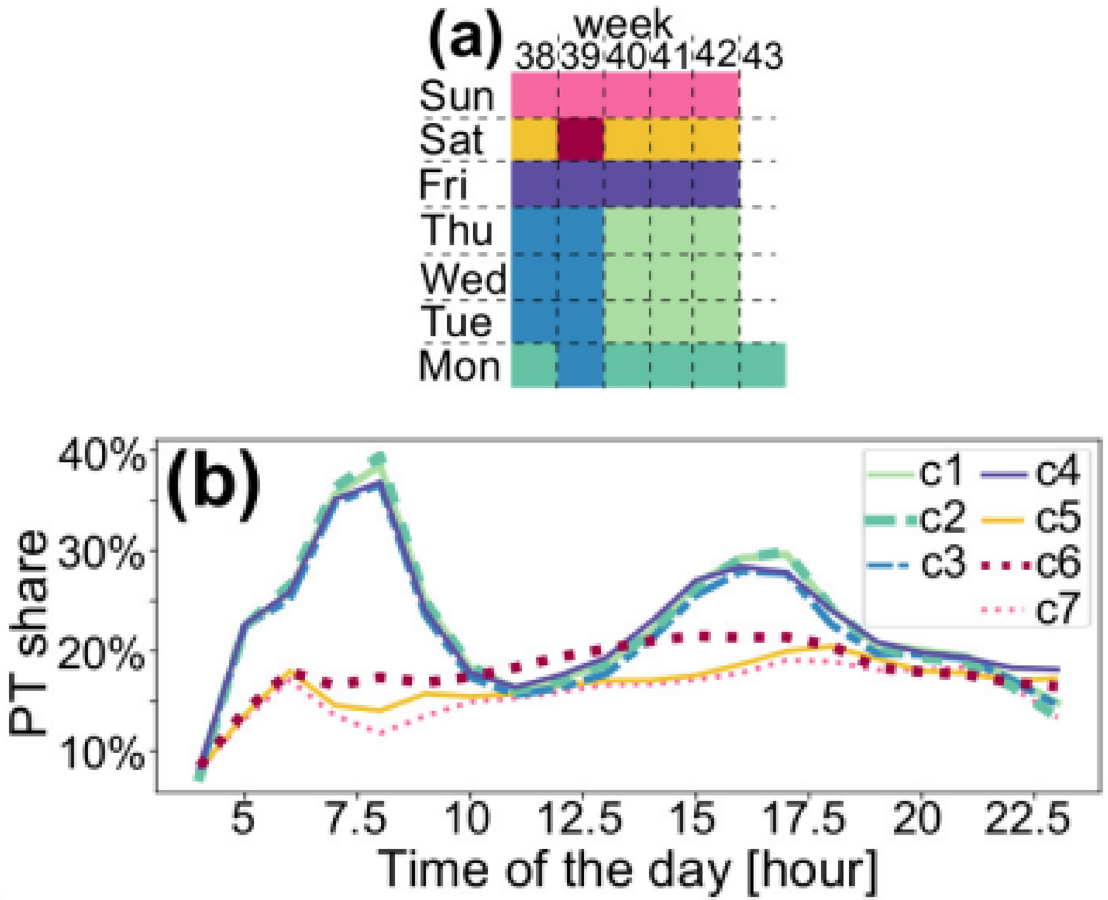
CTR

PT mode share analysis



Spatio-temporal PT mode share analysis for 7 day-types

- c6 (28th Sep) – PT mode share is larger about 5%, as other Saturdays in c5 cluster
- Mondays have a larger PT mode share during peaks
- Fridays have about a 10% larger PT mode share for late hours than other weekdays
- c1 has a larger PT share than cluster c3, does rainy and colder weekdays attract more travelers to PT.

PT mode share analysis

Regression analysis with socio-economic-weather-PTsupply context

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Zonal PT mode share correlation analysis

Indep. variable	corr
Monday	0.103
Tuesday	0.071
Wednesday	0.083
Thursday	0.081
Friday	0.074
Saturday	-0.188
Daily max precip-probability	0.07
Daily min temperature	-0.116
Daily max temperature	-0.058
Daily max wind speed	0.003
log(PT stops)	0.086
metro	0.193
tram	-0.098
train	0.292
bus	-0.156
age 0-15	-0.209
age 16-19	-0.112
age 20-24	0.277
age 25-39	0.189
age 40-59	-0.036
age 60 and more	-0.049
foreign background	0.070
median income	0.165
log(median income)	0.002
male	0.376
unemployed	0.254
pre-secondary education	0.015
secondary education	0.005
university-undergraduate	0.315
university-graduate-post	0.042
accommodation-owned	-0.209
accommodation-condominium	-0.086
accommodation-rent	0.383
registered vehicle	-0.348
households with children	-0.335
R^2	
adjusted R^2	
Prob(Omnibus)	
Condition number	

- **Positive correlations**
  - Weekdays, Mondays the most
  - Zone metro and train station ratio
  - Age 20 – 39 ratio, mostly 20-24
  - Male ratio in zone
  - Unemployed ratio in zone
  - Bachelor degree ratio in zone
  - Rented accommodation ratio in zone
- **Negative correlations**
  - Higher the minimal daily temperature lower the PT share
  - The tram (missing validations) or bus ratio
  - Age 0 – 10 ration, mostly 0-15
  - Ration of owned accommodation
  - Ratio of registered vehicles per households
  - Ration of households with children

Regression analysis

- Ordinary Least Squares (OLS) regression model
- Day-of-week, weather, income, education, PT supply, access to a private vehicle, and families with children all impact the zonal PT share and have significant explanatory and predictive power

		M1		M2	
Indep. variable	corr	coef	$P > \|t\|$	coef	$P > \|t\|$
Monday	0.103	0.0852	0.000	0.0784	0.000
Tuesday	0.071	0.0807	0.000	0.0727	0.000
Wednesday	0.083	0.0835	0.000	0.0761	0.000
Thursday	0.081	0.0824	0.000	0.0754	0.000
Friday	0.074	0.0819	0.000	0.0736	0.000
Saturday	-0.188	0.0121	0.001		
Daily max precip-probability	0.07	0.0056	0.165		
Daily min temperature	-0.116	0.0007	0.051		
Daily max temperature	-0.058	-0.0011	0.000		
Daily max wind speed	0.003	0.0003	0.642		
log(PT stops)	0.086	0.0578	0.000	0.0907	0.000
metro	0.193	3.5852	0.000	0.3645	0.000
tram	-0.098	3.9381	0.000	0.1990	0.000
train	0.292	5.2703	0.000	1.7791	0.000
bus	-0.156	3.4089	0.000		
age 0-15	-0.209	-9.8436	0.000		
age 16-19	-0.112	-22.441	0.000		
age 20-24	0.277	-3.7796	0.000		
age 25-39	0.189	- 4.8367	0.000		
age 40-59	-0.036	- 3.7243	0.000		
age 60 and more	-0.049	-4.2791	0.000		
foreign background	0.070	-0.4419	0.000		
median income	0.165	-0.0030	0.000		
log(median income)	0.002			0.0154	0.000
male	0.376	5.9922	0.000		
unemployed	0.254	3.2880	0.000	2.0984	0.000
pre-secondary education	0.015	0.4481	0.643	-4.1979	0.000
secondary education	0.005	2.4897	0.000	1.3706	0.000
university-undergraduate	0.315	0.1073	0.874	3.5796	0.000
university-graduate-post	0.042	1.6039	0.003		
accommodation-owned	-0.209	-0.0133	0.960	1.0542	0.000
accommodation-condominium	-0.086	-1.5476	0.000		
accommodation-rent	0.383	-1.9679	0.000	-0.0698	0.005
registered vehicle	-0.348	-2.1761	0.000	-2.1204	0.000
households with children	-0.335	-6.8592	0.000	-5.2320	0.000
R^2		0.985		0.970	
adjusted R^2		0.985		0.969	
Prob(Omnibus)		0.818		0.922	
Condition number		7.09e+04		1.20e+03	

What next?

What next?

- A mode choice component will be added to analyze multimodal traffic management
- Analysis and overview of typical days, route choice, and demand in Stockholm
- Analysis of incidents
- Simulation with mesoscopic traffic model (Dynameq)

Tack så mycket!

Frågor?

Anna Danielsson, anna.a.danielsson@liu.se

Matej Cebecauer, matej.cebecauer@abe.kth.se