At least 3 decades' research in travel behaviors

Cynthia Chen
University of Washington, Seattle

Background

The larger context

- *link to many grand problems of our society (e.g, energy consumption, air pollution, obesity, and quality of life…)*
- *matter directly individuals' upward "mobility"*
- *addressing these issues must engage human factors*

Supply based

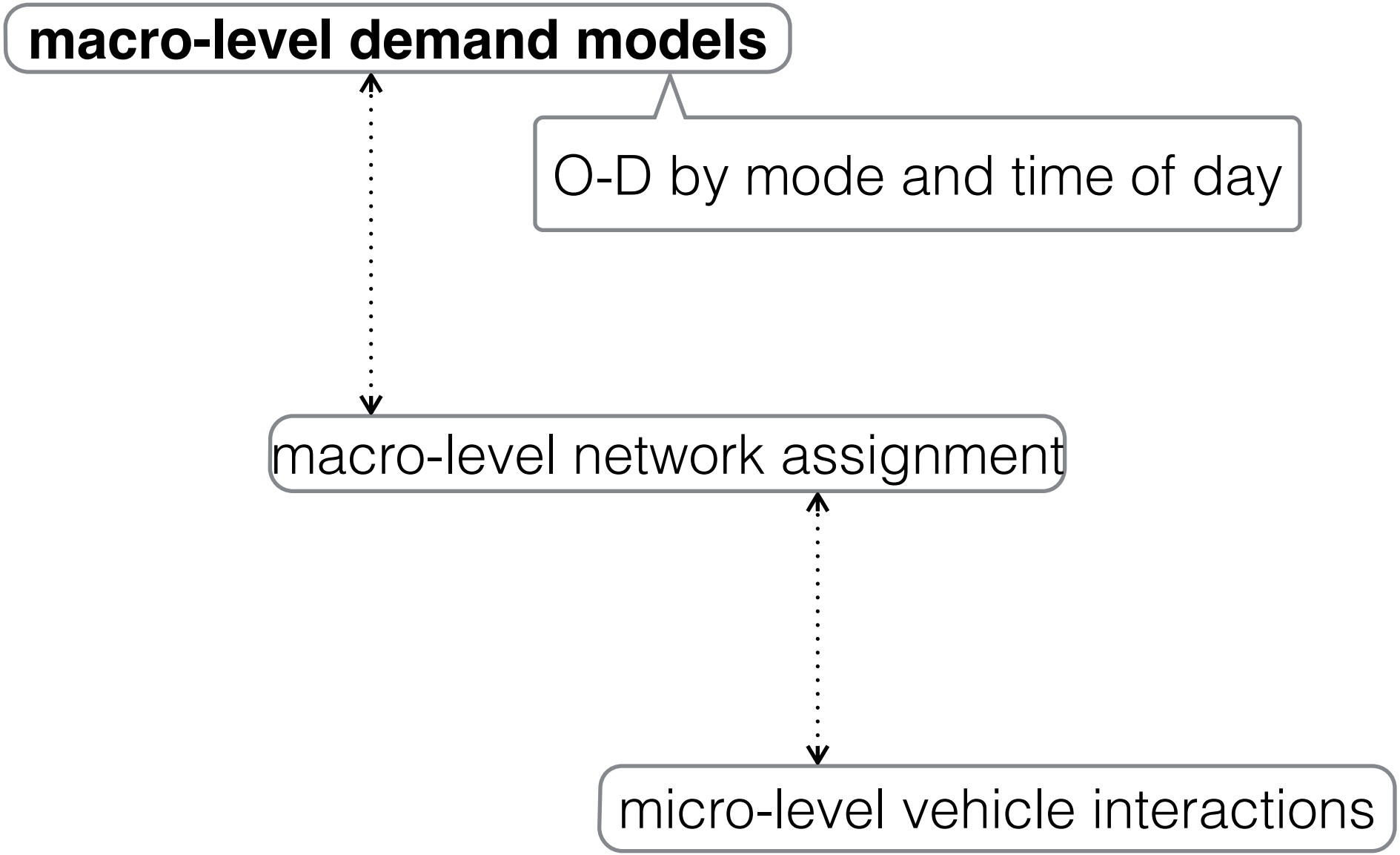
Demand based

3 charges

- Provide guidance on the kinds and scale of policies needed
- Quantify the effect of policies
- Identify factors and mechanisms that fundamentally influence the course of a phenomenon

Major sub-fields

- movement patterns
- model development
- behavioral factors


macro-level demand models
O-D by mode and time of day
macro-level network assignment
micro-level vehicle interactions

Data

Household travel surveys

- **data of active solicitation**
- available at the national level and many metropolitan levels
- most often, cross-sectional survey (many subjects but one time point)
- contains three modules
  - household and person related (socio-demographics)
  - trip related (typically for 24 hours, or one day)
  - vehicle related

Household travel surveys

- Sampling
  - randomly selected from geographic subareas within the study region
  - oversampling typically done at subarea level or for specific populations
  - non-probability sampling as an option
- recruitment: first-class mail or telephone
- data retrieval: online instrument, paper-based, CATI
- GPS subsample sometimes available

NATIONAL HOUSEHOLD TRAVEL SURVEY

TRAVEL DIARY

At the beginning of my travel day (4:00 a.m.) I was:
☐ Home ☐ Some other place

WHERE did you go? (Name of place)	What **TIME** did you start and end each trip?		**WHY** did you go there?	**HOW** did you travel?	How **FAR** was it? (blocks or miles)
	Started at:	Arrived at:			
EXAMPLE: *West Park Theater*	*2:00 p.m.*	*2:55 p.m.*	*To see a movie*	*walk, bus, walk*	*6 miles*
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					

1 2 3 4 5 6

Wednesday, February 11, 2009

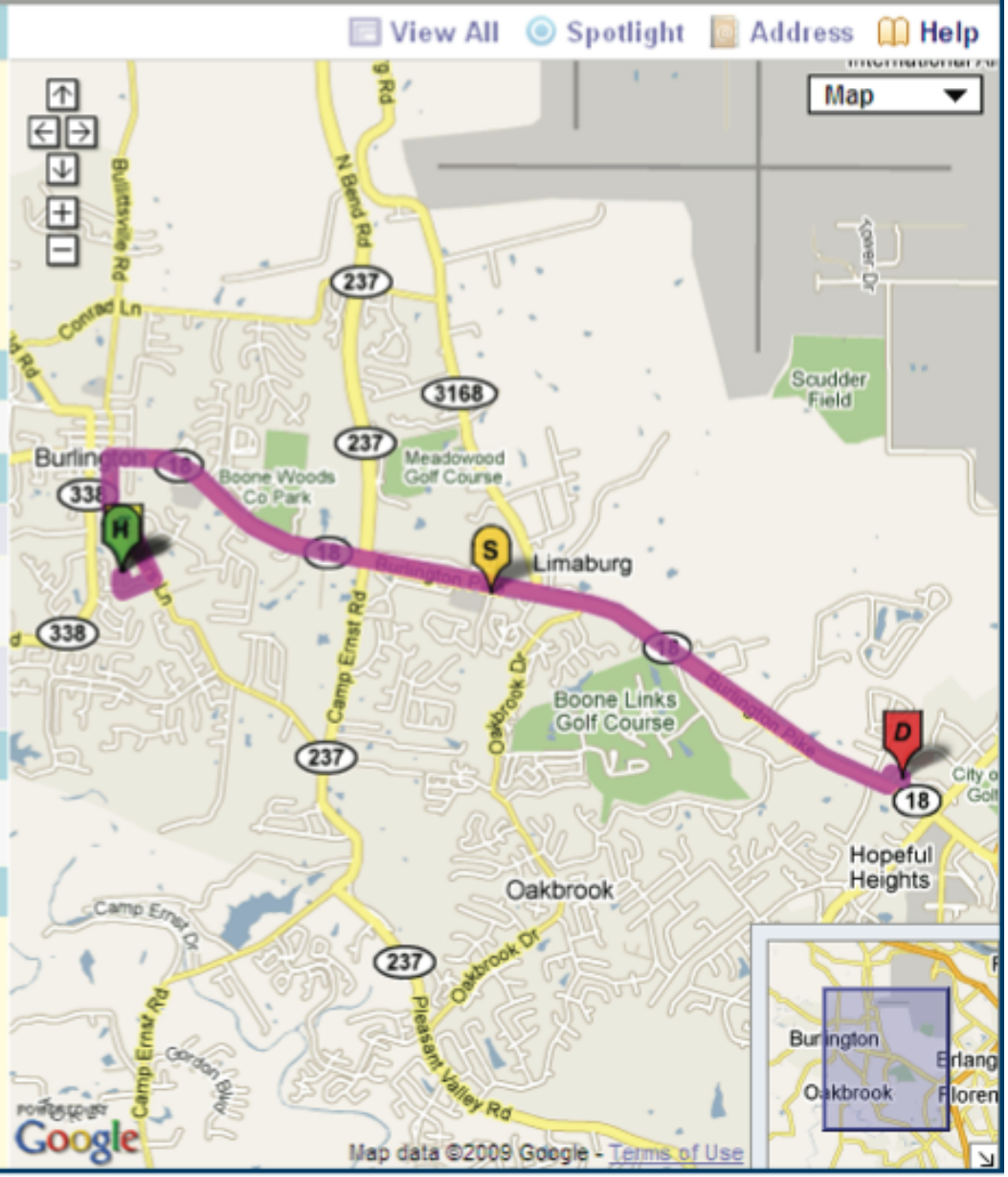
The map on the right displays one of your travel events corresponding to the details below. You need to:

- Click on each **red** question mark to update that detail.
- Click on each **orange** item to either confirm or update that detail.

You can also **Insert** missing stops and/or **delete** stops that are not correct.
After each **red** and **orange** item is updated, it will turn **green**.
After ALL the **red** and **orange** items become **green**, you will see a **continue** link at the bottom of the page.

4:45 PM -> 4:47 PM	**Stay on "D"**	
Activity that best describes what you were doing?	?	
4:47 PM -> 5:02 PM	**"D" -> "E"**	
What means of travel did you use?	?	
Which of the following household members traveled with you to the next place?	?	
Is there a stop missing during this travel? If yes, please insert a stop by clicking **Insert**.	**Insert A Stop**	
5:02 PM -> 6:20 PM	**Stay on "E"**	
If it was not a real stop, please delete this stop by clicking **Delete**.	**Delete This Stop**	
6:20 PM -> 6:33 PM	**"E" -> Other Place**	

You may return to this travel at any time by clicking on the **green** numbered circle above.



Sample records from a regional household travel survey.

hhid	pid	actno	ptype	depart	arrive	tripdur	actdur	Latitude	Longitude
1200	1	1	1	650	300		230	34 7 48.87 N	118 6 27.56 W
1200	1	2	2	1437	740	50	417	34 8 43.56 N	118 8 58.78 W
1200	1	3	1	259	1530	53	629	34 7 48.87 N	118 6 27.56 W

hhid, household id; pid, person id; actno, activity number; ptype, type of activity (1-home; 2-work); depart, departure time from the location of the corresponding activity (in military format: hhmm); arrive, arrival time at the location of the corresponding activity (in 24 h); tripdur, duration of the trip to arrive at the corresponding activity (in minutes); actdur, duration of the activity in minutes.

Recent/Current Projects

RECENTLY COMPLETED PROJECTS / 2010-present

YEAR	AGENCY/PROJECT	STATE	SAMPLE SIZE	SAMPLING RATE	MODEL TYPE	METHODS	GPS SAMPLE
2010	North Front Range Metropolitan Planning Organization (NFRMPO)	CO	1,505	1.1%	Activity	Unknown	0%
2011	Community Planning Association of Southwest Idaho (COMPASS)	ID	2,000	0.9%	Trip	Phone, paper	0%
2011	Genesee Transportation Council (GTC)	NY	3,671	1.1%	Trip	Web, phone	0%
2011	Atlanta Regional Commission (ARC)	GA	10,278	0.6%	Trip/Activity	Web, phone, paper	10%
2011	Southeastern Wisconsin Regional Planning Commission (SEWRPC)	WI	16,500	2.1%	Trip	Unknown	0%
2011	New York Metropolitan Transportation Council (NYMTC)	NY	18,966	0.2%	Trip	Web, phone	10%
2011	Metropolitan Washington Council of Governments (MWCOG)	DC	4,800	0.3%	Activity	Phone, paper	0%
2012	Twin Cities Metropolitan Council	MN	10,362	0.9%	Trip	Web, phone, paper	0%
2012	Wasatch Front Regional Council (WFRC) and Utah DOT	UT	9,159	1.0%	Trip	Web, phone	0%
2012	Metrolina Regional Household Travel Survey	NC	4,231	0.9%	Activity	Phone, paper	0%
2012	Nashville Area Metropolitan Planning Organization	TN	6,500	2.6%	Activity	Phone, web	10%
2013	California Department of Transportation (CA DOT)	CA	42,000	0.3%	Activity	Web, phone, paper	13%

Name of the survey*	Year	Original focus	Location(s)	Period	Resolution: geocoding	Resolution: purposes	Persons	Trips
Uppsala Household Travel Survey	1971	Travel behaviour	Uppsala, Sweden	35 days	Building	All purposes	144	23,000
Mobidrive: Dynamics and routines of travel behaviour	1999	Stability of temporal patterns	Karlsruhe and Halle, Germany	42 days	Street block	All purposes	361	52,000
Borlänge GPS study (ISA Rätt Fart)	2000-2002	Speeding behaviour	Borlänge, Sweden	Up to 80 weeks	Trip ends: GPS; unique locations: pre-defined clusters of trip ends	Unknown, potentially all	189 veh.**	240,000 car trips
Leisure study (SVI Gesetz-mässigkeiten des Wochenend-Freizeit-verkehrs)	2002	Leisure travel behaviour and activities	Zürich, Switzerland	84 days	Post-code level	31 leisure purposes	75	9,900 leisure activities
Thurgau diary (SVI Study of the stability of transport behaviour)	2003	Stability of temporal patterns	Frauenfeld and villages in the Swiss canton of Thurgau	42 days	Building	All purposes	230	37,000
Copenhagen GPS study (AKTA Road Pricing Experiment in Copenhagen)	2001-2003	Route choice under road pricing	Copenhagen, Denmark	18-24 weeks	Trip ends: GPS; unique locations: pre-defined clusters of trip ends	Unknown, potentially all	500 veh.	250,000 car trips
Atlanta GPS study (Commute Atlanta Study)	2004-2006	Travel behaviour; test of policy measures such as pricing	Atlanta, USA	Up to two years	Trip ends: GPS; unique locations: pre-defined clusters of trip ends	Unknown, potentially all	Approx. 500 veh.	Approx. 1,000,000 car trips

Emerging data sources

- **data of passively generated**
  - *mobile phone data*
    - *CDR*
    - *sightings*
  - social media data
  - transit smart-card data
  - taxi data

Call Detail Record

X	Y	ID	TIME	DURATION (sec)
195925	32464	J000001	82141	81
195925	32464	J000001	82456	75
195018	31555	J000002	82100	140

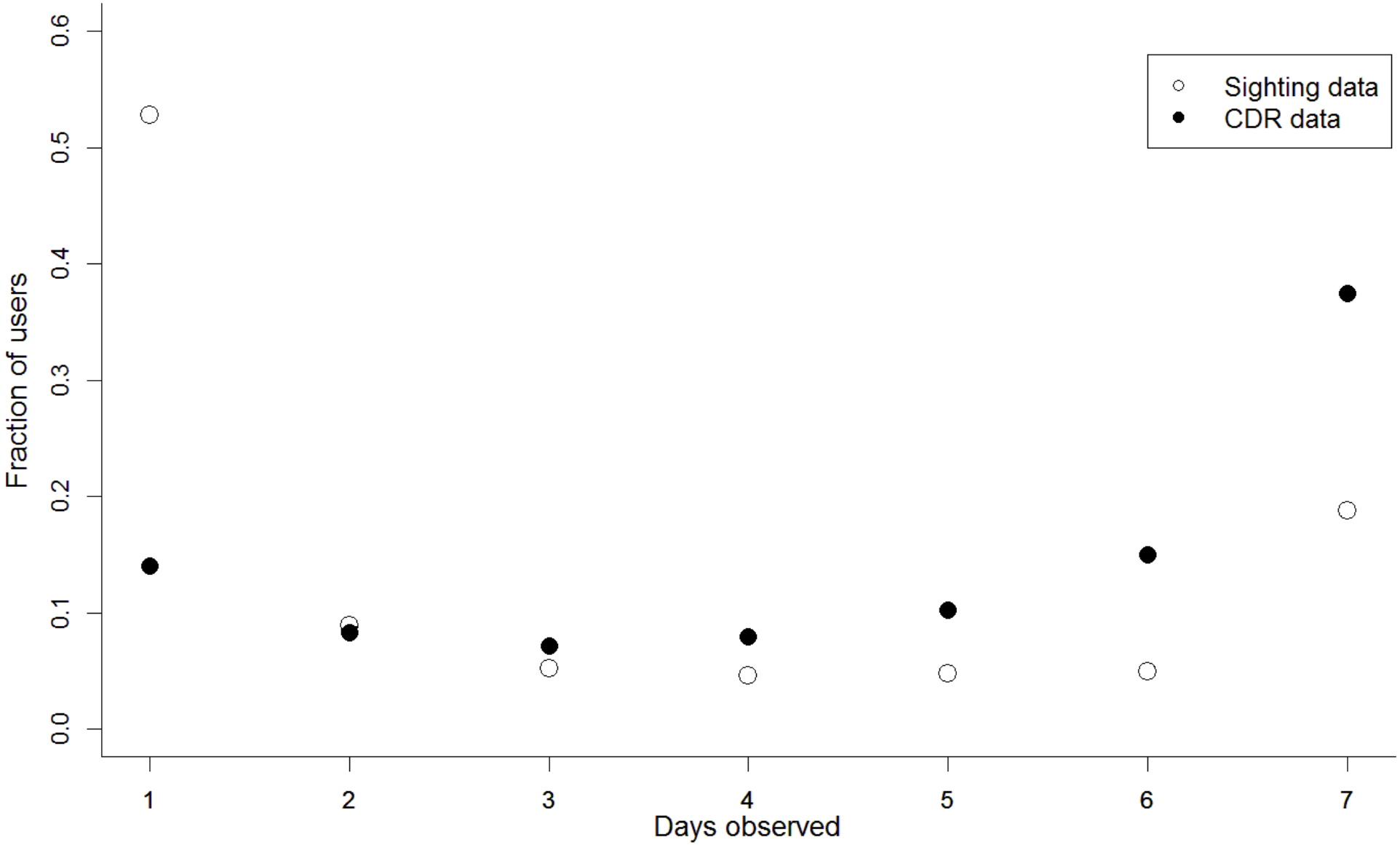
Number_1	Number_2	Call type	Date	Time	Duration (sec)
J188760		02	07-21-07	00:20:12	2
J077553	J125738		07-21-07	00:00:38	238
J394476		01	07-21-07	00:13:06	22

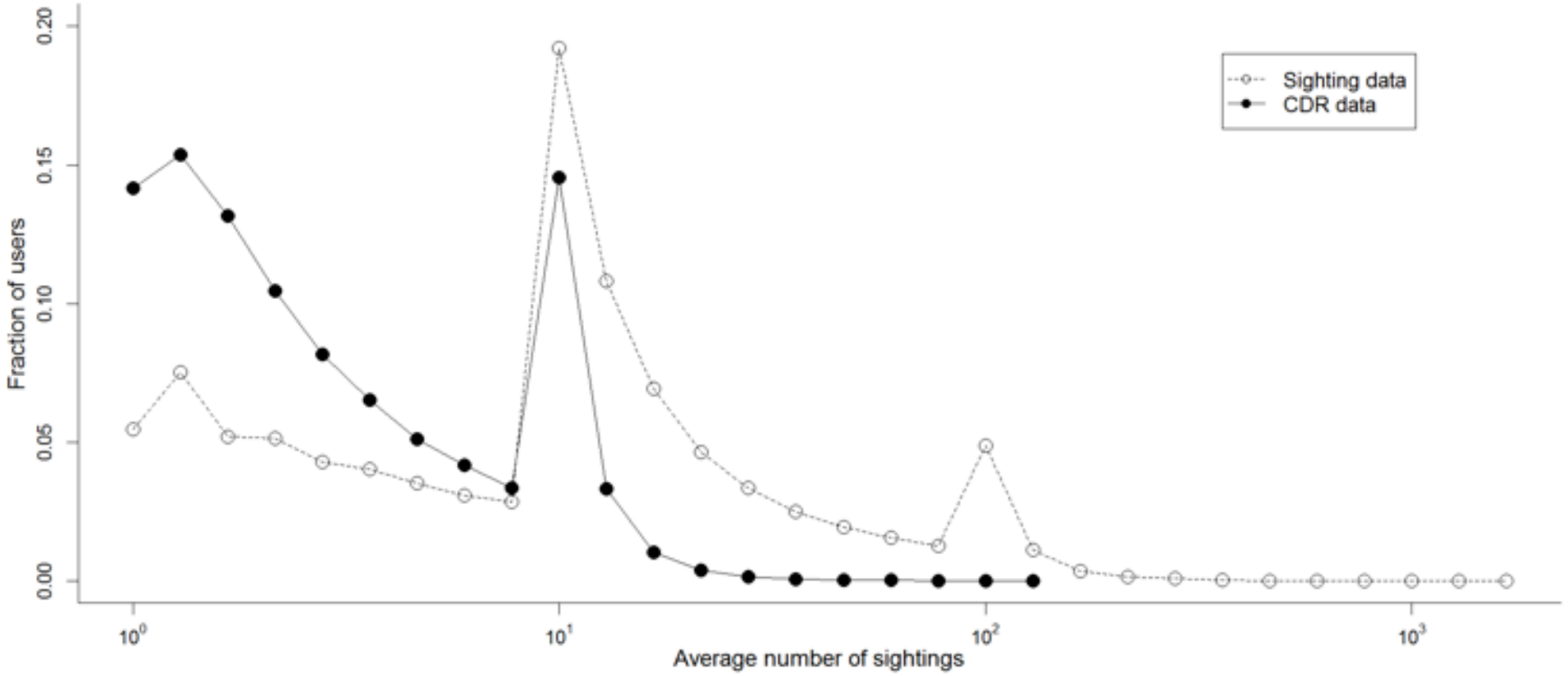
Sightings data

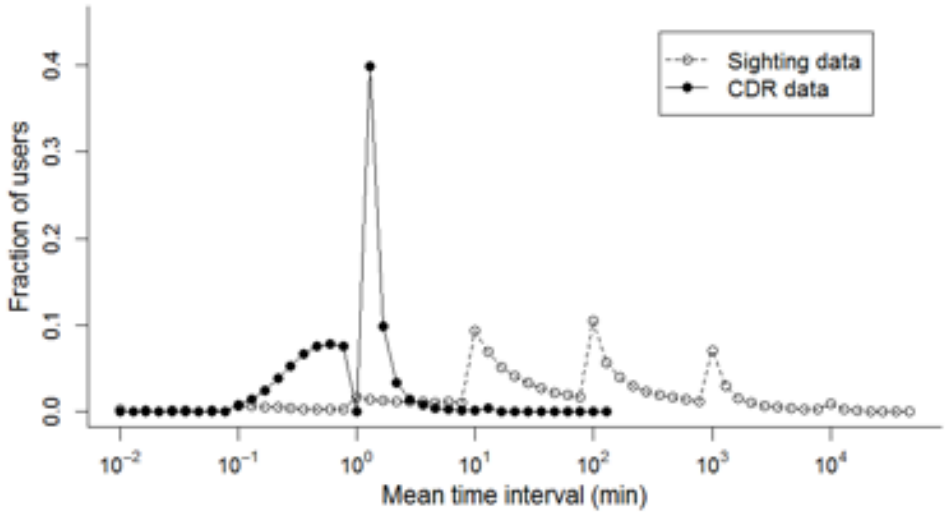
ID	TIME[a]	LOCATION[b]
3X35E90	1319242582	34.044162|-112.454400
3X35E90	1319242583	34.044059|-112.455550
3X35E90	1319301785	34.044392|-112.453519

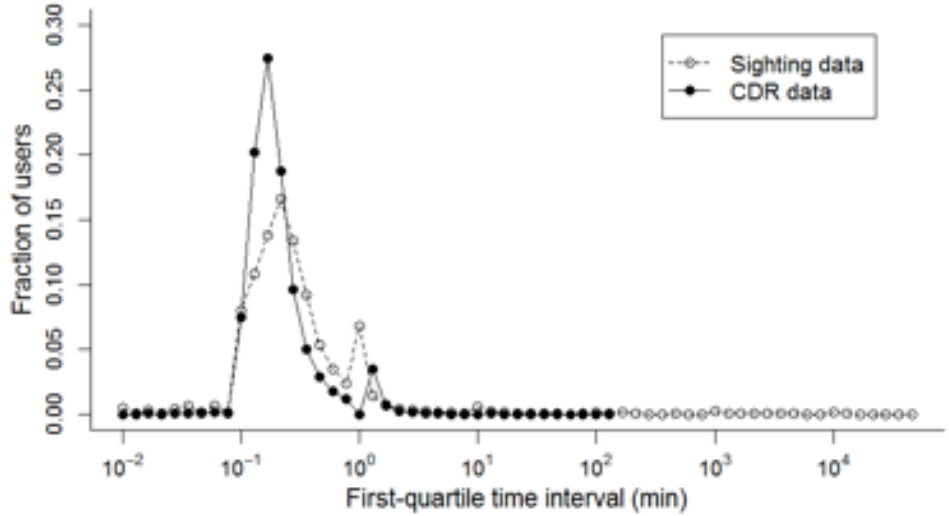
Some differences

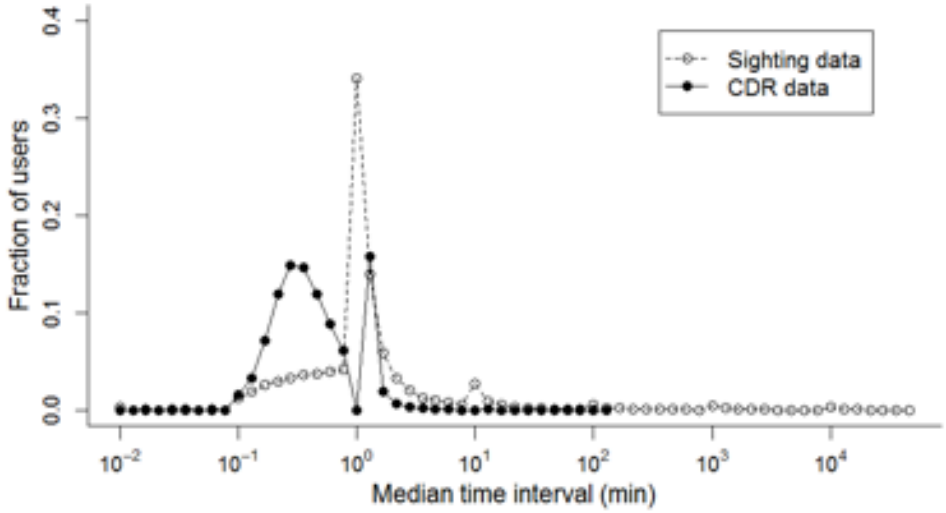
- temporal resolution
- spatial resolution
- user interactions

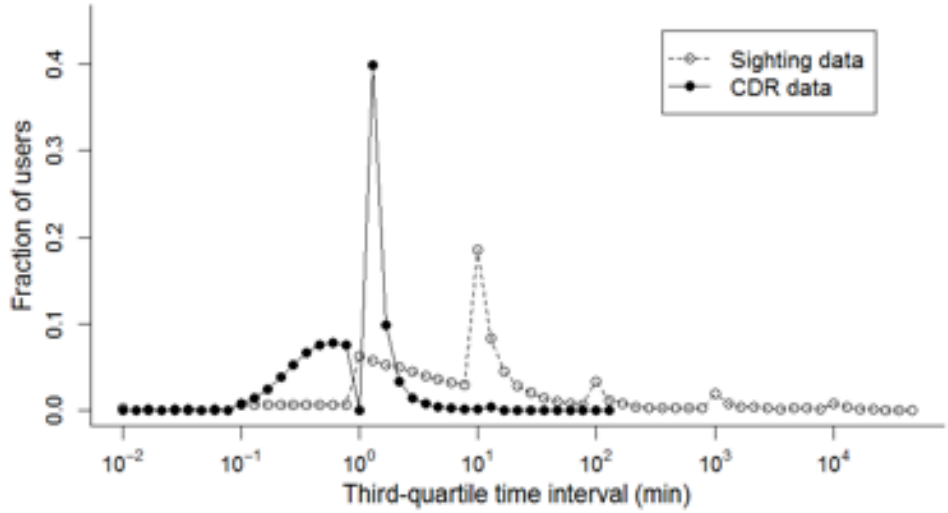

Sighting data
CDR data
Fraction of users
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
7
Days observed


Sighting data
CDR data
Fraction of users
0.00
0.05
0.10
0.15
0.20
10^0
10^1
10^2
10^3
Average number of sightings


Sighting data
CDR data
Fraction of users
0.0
0.1
0.2
0.3
0.4
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Mean time interval (min)


Sighting data
CDR data
Fraction of users
0.00
0.05
0.10
0.15
0.20
0.25
0.30
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
First-quartile time interval (min)


Sighting data
CDR data
Fraction of users
0.0
0.1
0.2
0.3
0.4
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Median time interval (min)


Sighting data
CDR data
Fraction of users
0.0
0.1
0.2
0.3
0.4
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Third-quartile time interval (min)

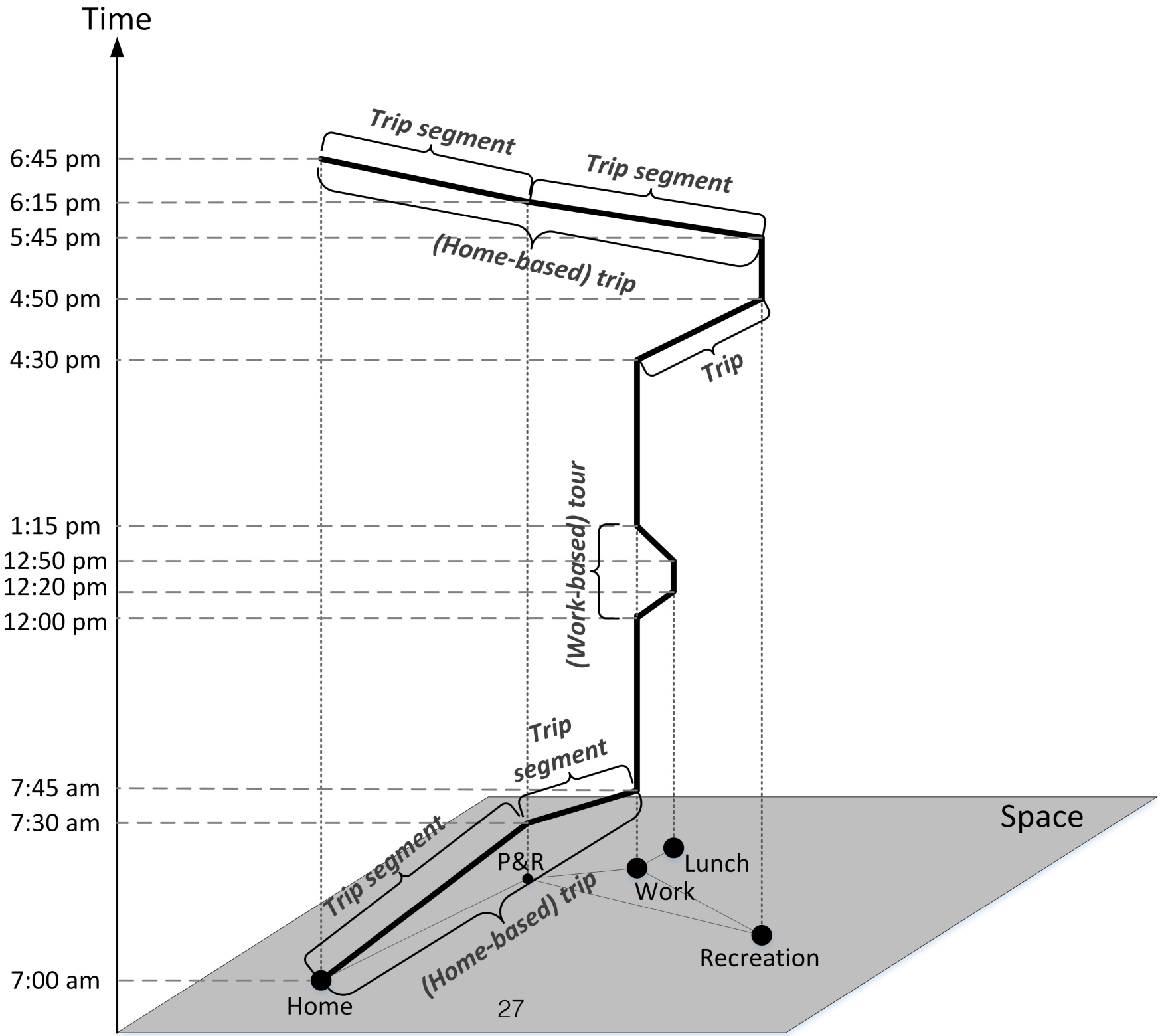
Concepts and measurements

Household travel surveys

Travel as a derived demand

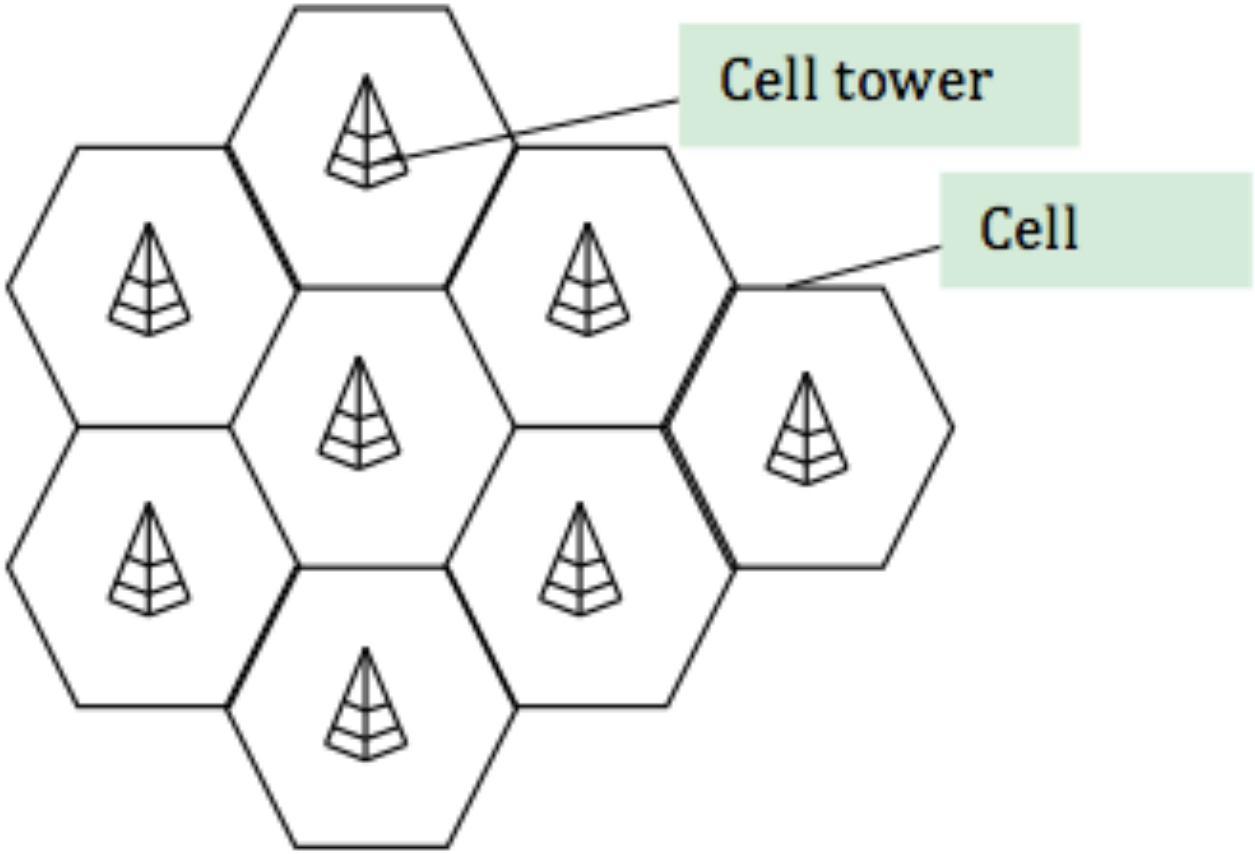
What is a trip?

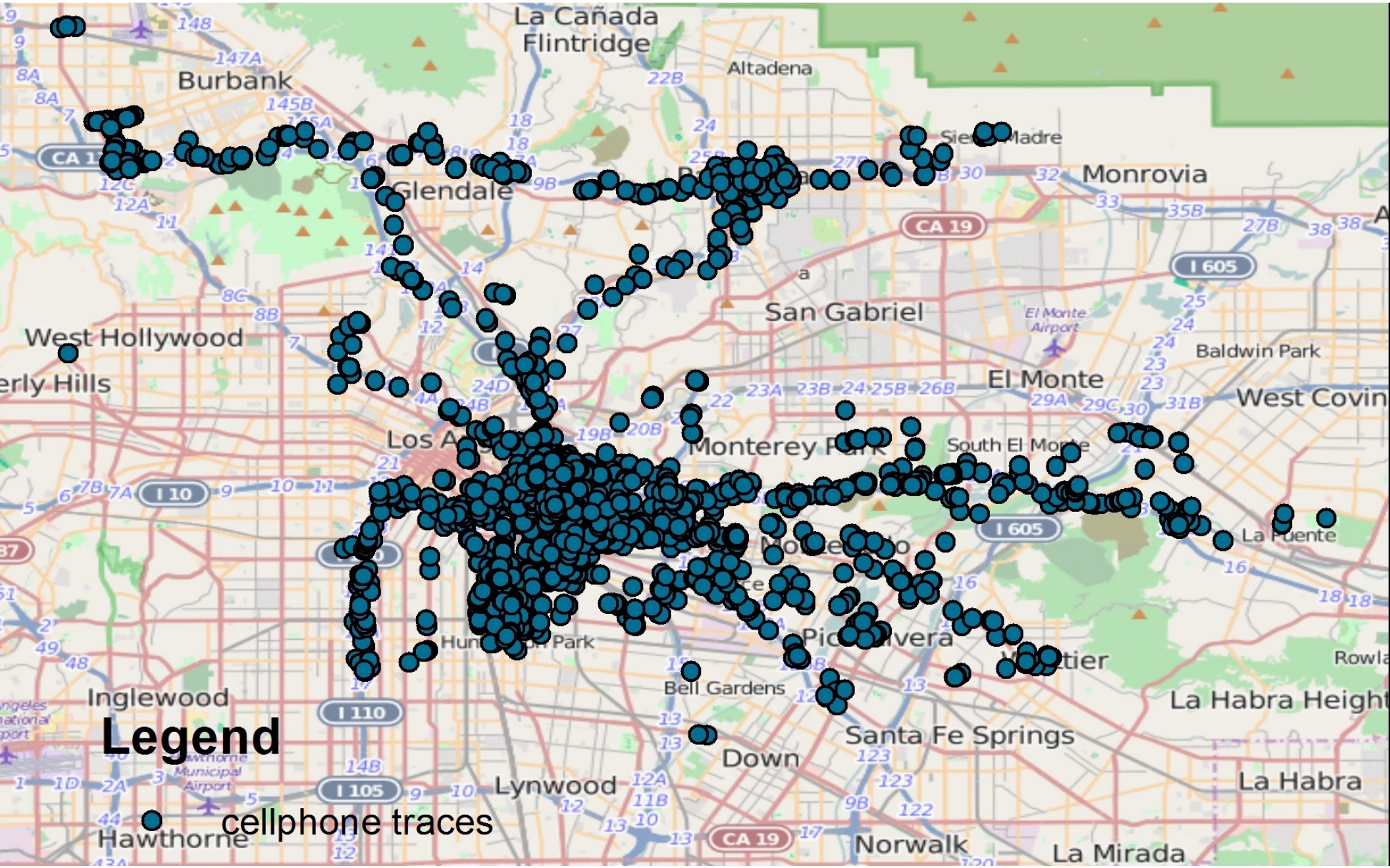
- A movement between two activity locations
- Definition of a trip depends on the definition of "*what is an activity"*
  - kinds of activity and purposes
  - duration
  - effort required to undertake the activity (e.g, physical or monetary)
  - group size and composition
  - urgency of activity
  - etc.


Time
6:45 pm
6:15 pm
5:45 pm
4:50 pm
4:30 pm
1:15 pm
12:50 pm
12:20 pm
12:00 pm
7:45 am
7:30 am
7:00 am
Trip segment
Trip segment
(Home-based) trip
Trip
(Work-based) tour
Trip segment
Trip segment
(Home-based) trip
Space
P&R
Lunch
Work
Recreation
Home

Passively generated mobile phone data

Oscillation

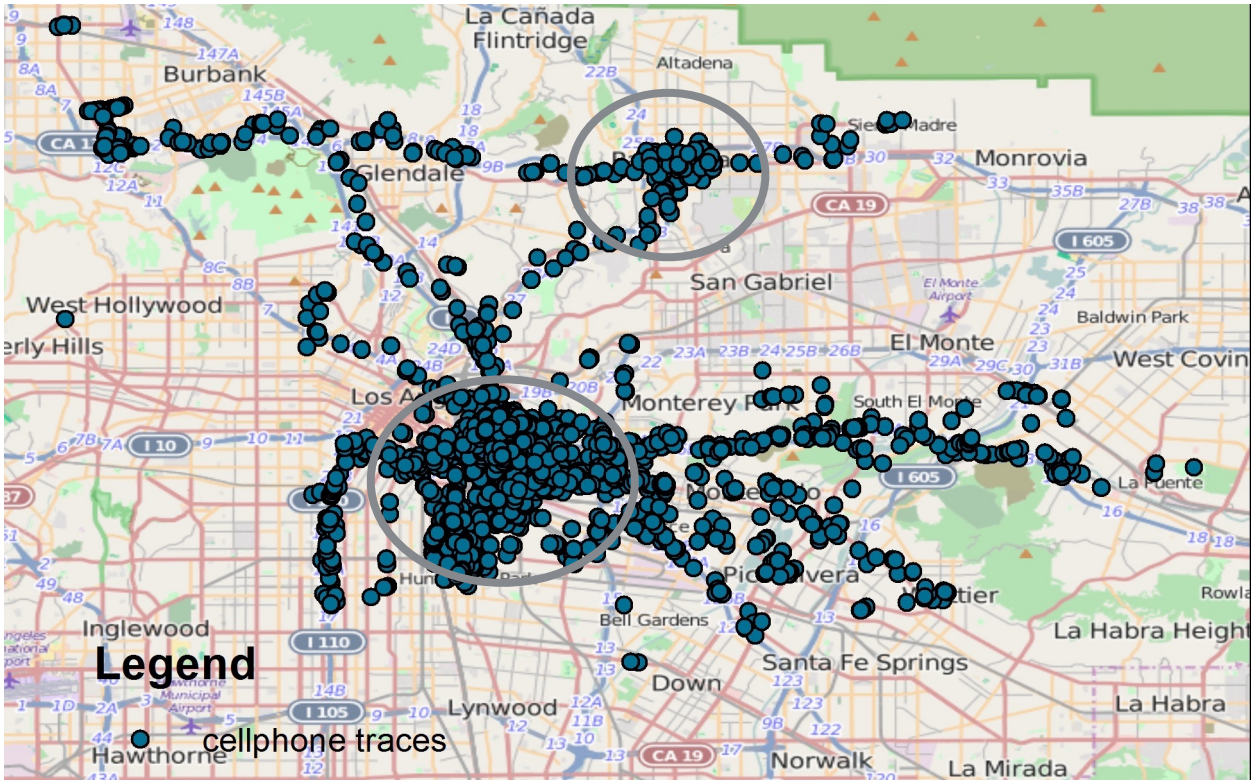



Legend
cellphone traces
La Cañada Flintridge
Altadena
Burbank
Glendale
Monrovia
San Gabriel
El Monte
Baldwin Park
West Hollywood
Monterey Park
South El Monte
La Puente
Bell Gardens
Inglewood
Santa Fe Springs
Down
Lynwood
La Habra
Hawthorne
Norwalk
La Mirada
CA 19
I 605
I 10
I 110
I 105

From traces to locations

Methods

- frequency-based
- clustering
  - distance based
  - time based
  - density based
  - model-based



Inferring types of locations

Methods

- frequency-based
- behavior-based
- model-based

Inferring mode and route choices

Route choice

- use intermediate points between O-D
- not use intermediate points (apply assignment techniques)

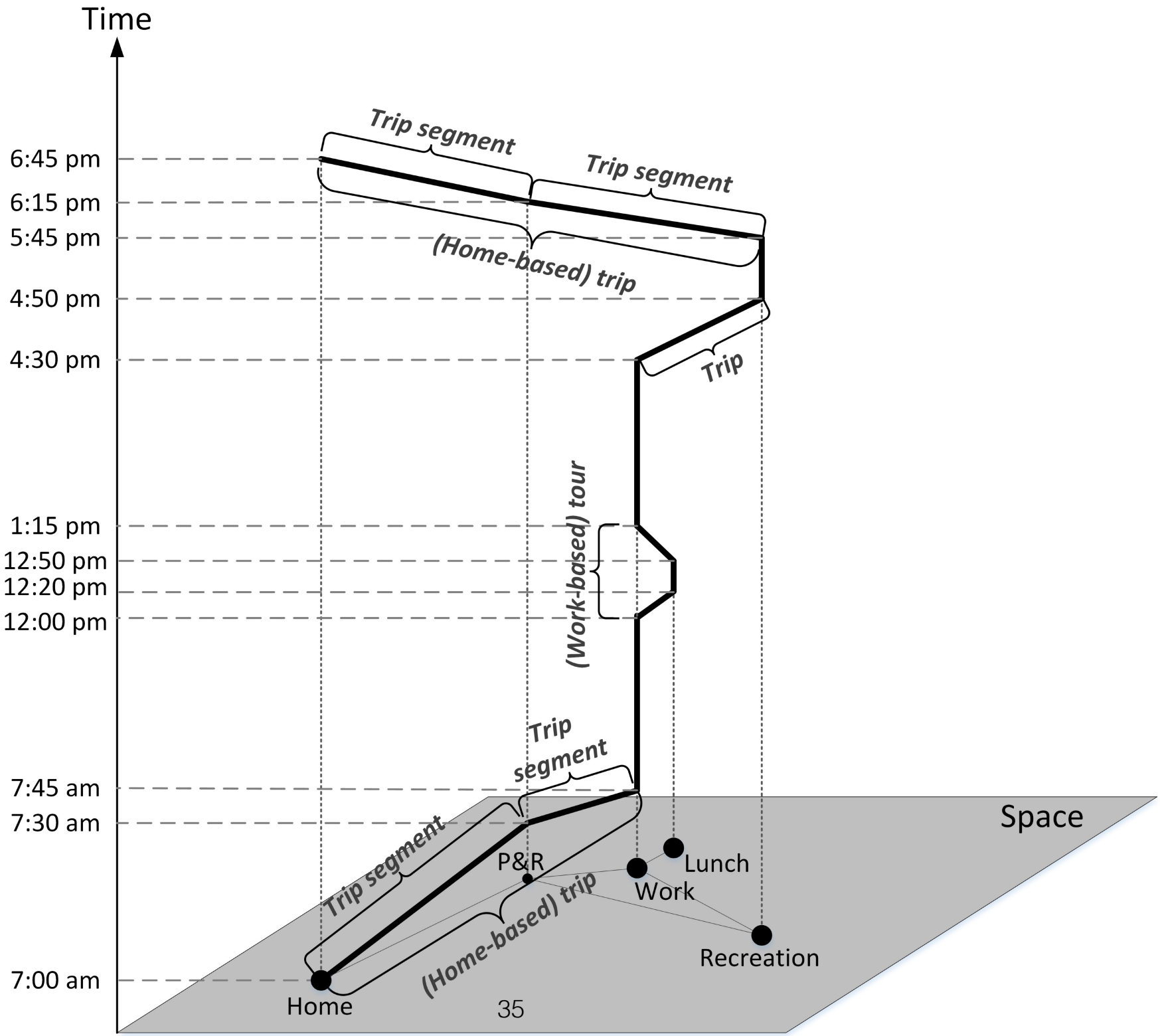
Mode choice

- speed-based

Validation: nearly NONEXISTENT

A FEW EXAMPLES

- comparing two different populations
- comparing between different scales (individuals vs regional levels)
- comparing the same sample, the same level (individual levels), using a simulation dataset


Time
6:45 pm
6:15 pm
5:45 pm
4:50 pm
4:30 pm
1:15 pm
12:50 pm
12:20 pm
12:00 pm
7:45 am
7:30 am
7:00 am
Trip segment
Trip segment
(Home-based) trip
Trip
(Work-based) tour
Trip segment
Trip segment
(Home-based) trip
Space
P&R
Lunch
Work
Recreation
Home

Movement patterns

Results from TB literature

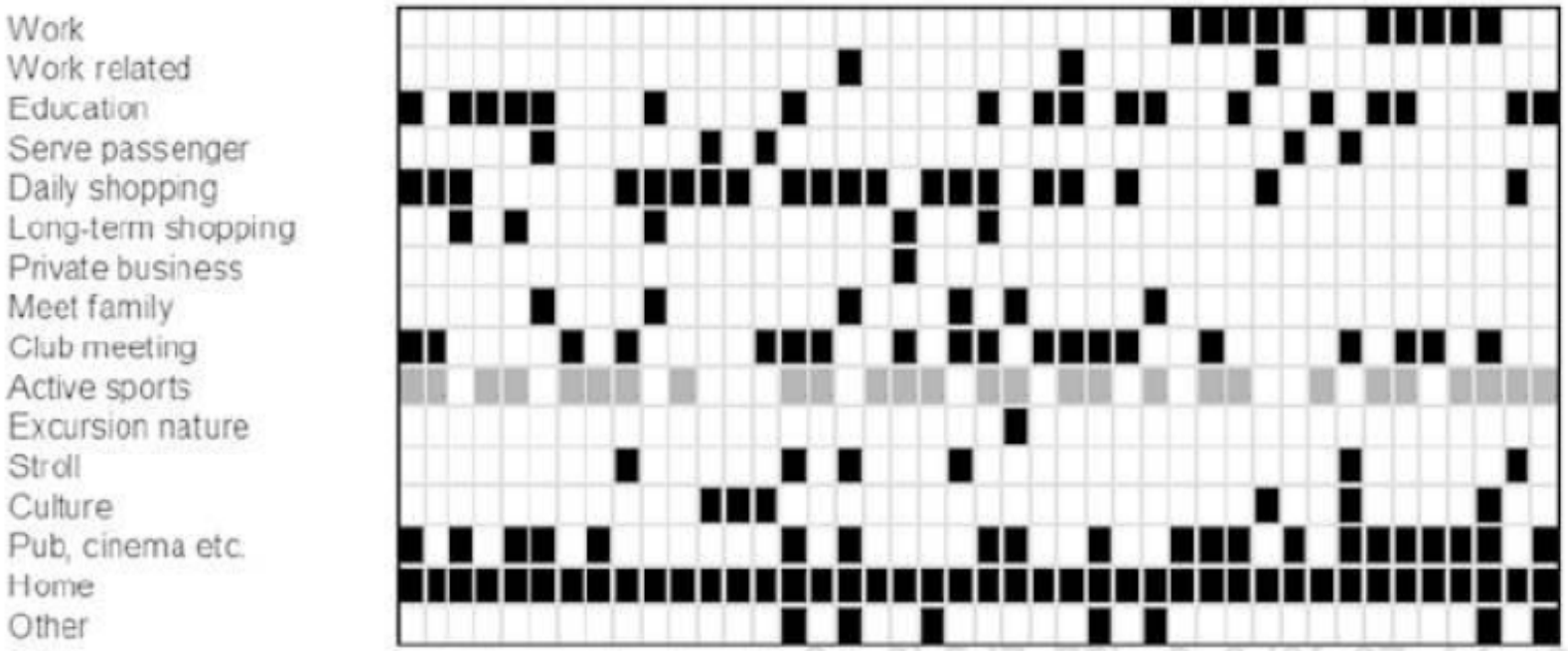
- habitual or routine behavior
- rhythmic patterns
- variability
- equilibrium of behavior
- dynamics
- variety seeking

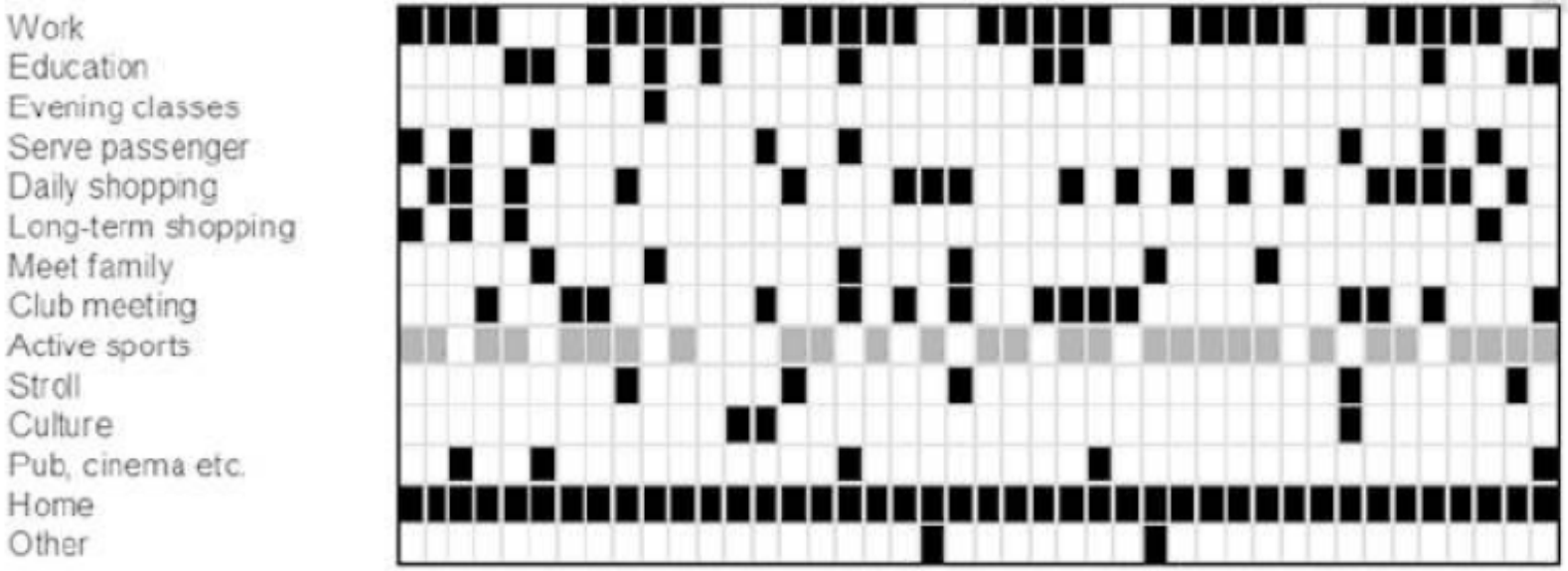
(Ir)regularity in travel behaviors

What has been measured?

- *daily trip rates*
- *daily trip distances*
- *action space*
- *activity time use*
- unique trip sequences
- similarity indexes

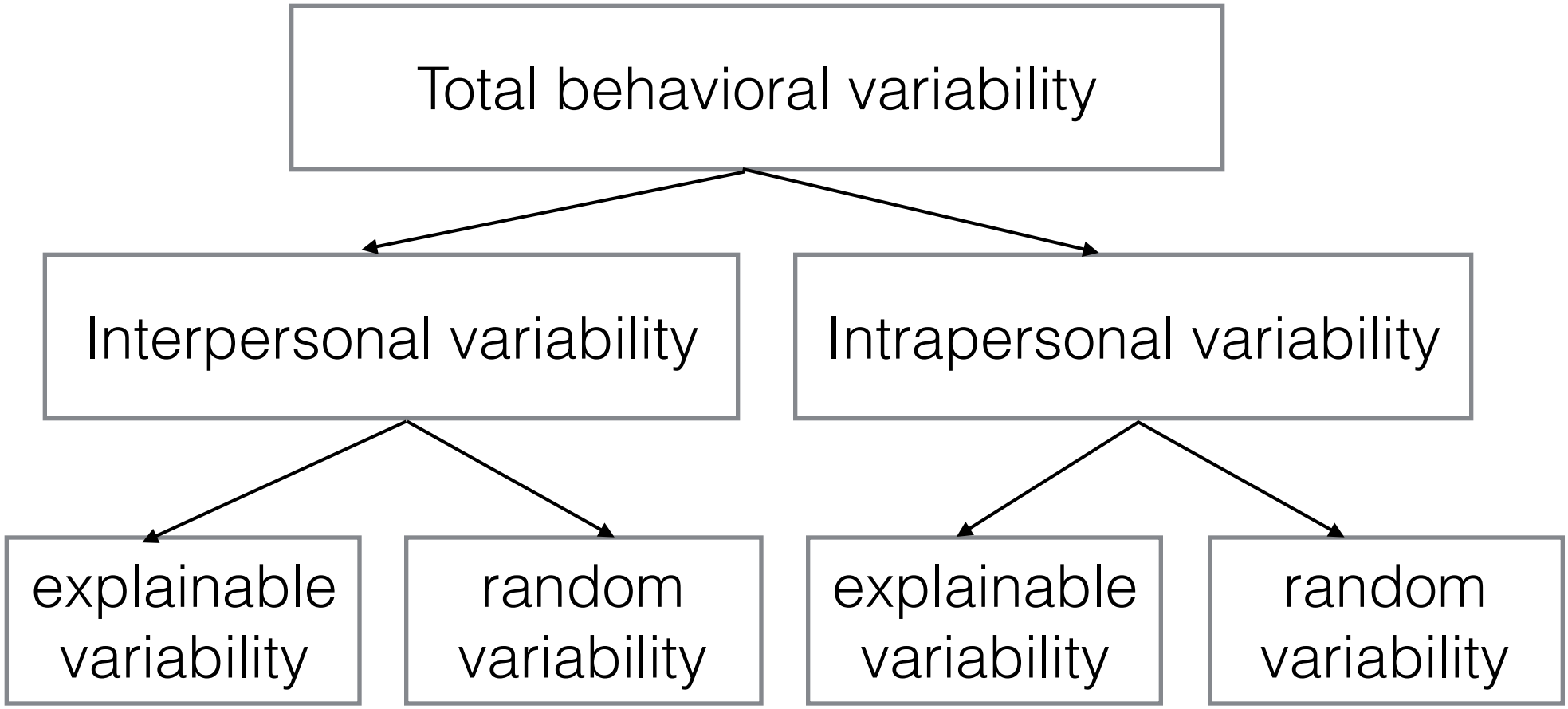
Two-person household.
Top: male, 37, homemaker; bottom: female: 35, works full time:





Susan Hanson et al (1980s)

- habitual and routine behavior dominates
- developed similarity indexes that reveal little similarity in the behavior of a single traveler on different days

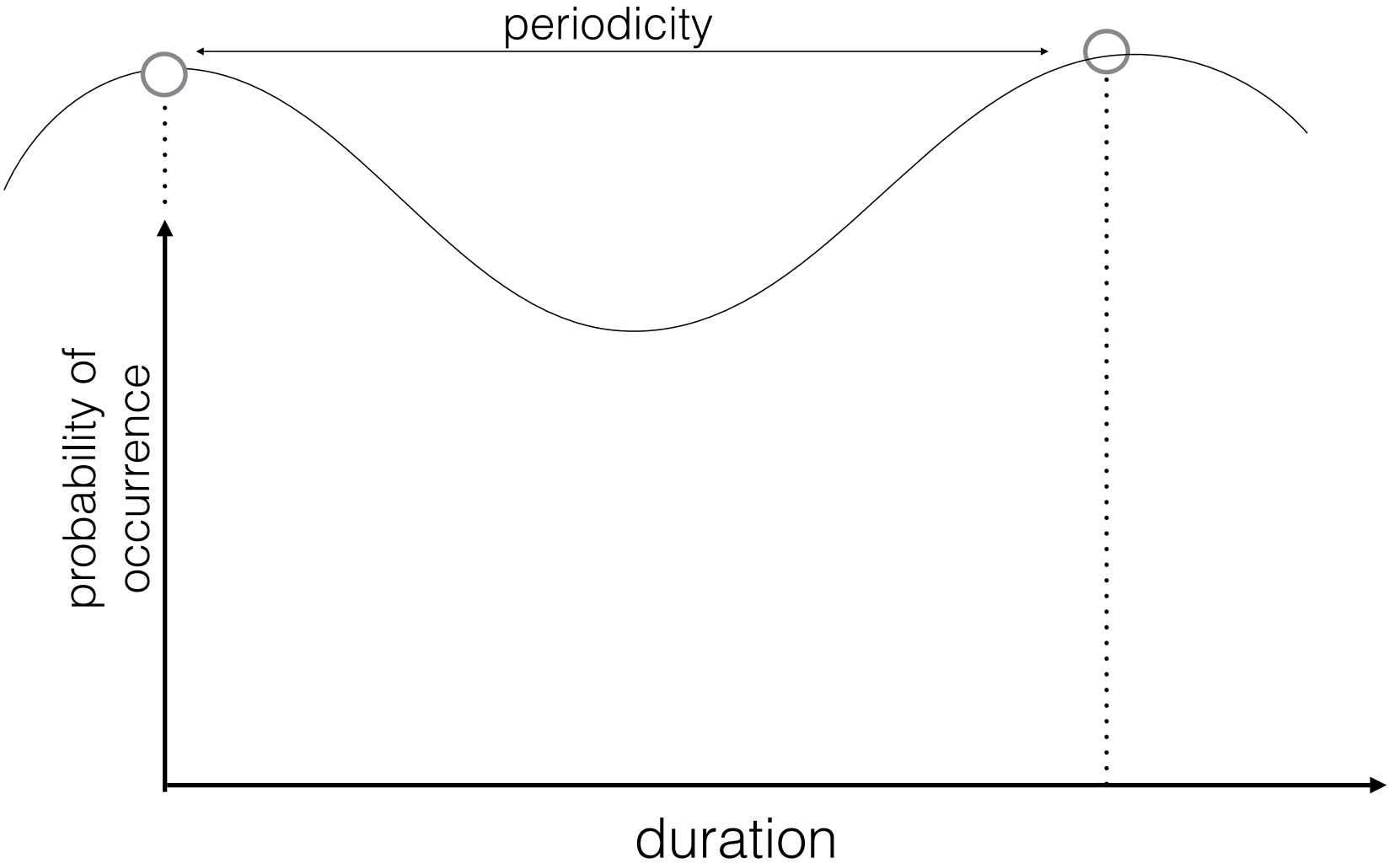

Total behavioral variability
Interpersonal variability
Intrapersonal variability
explainable variability
random variability
explainable variability
random variability

Pas, 1987

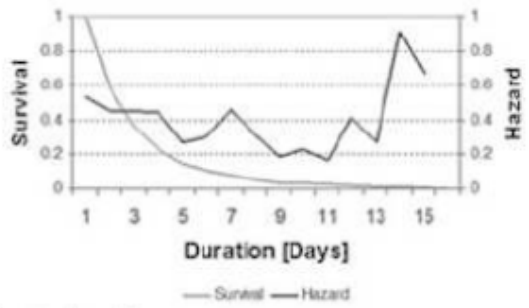
Mahmassani et al (1990s)

- day-to-day dynamics on departure time choice, trip training and route choice
- stronger propensities for changing route choices than departure time choices

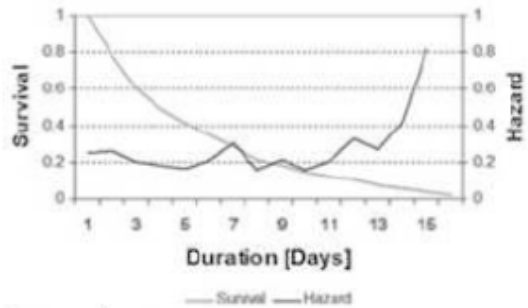
Axhausen et al (2000s)



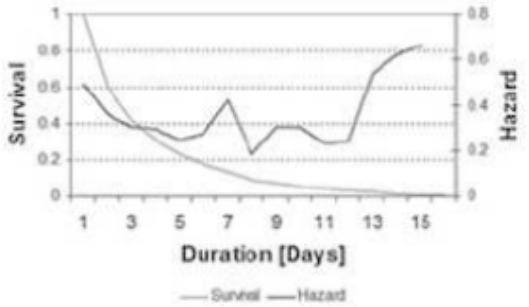
Daily shopping



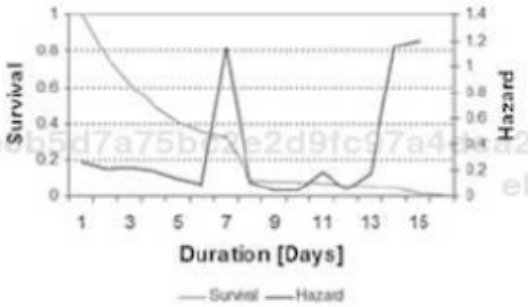
Long-term shopping



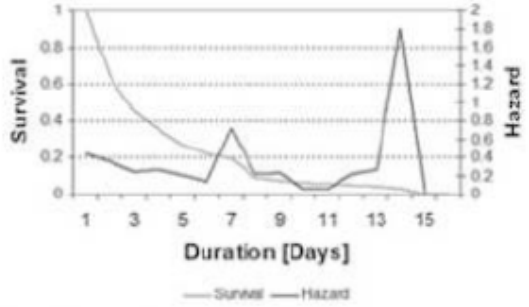
Private business



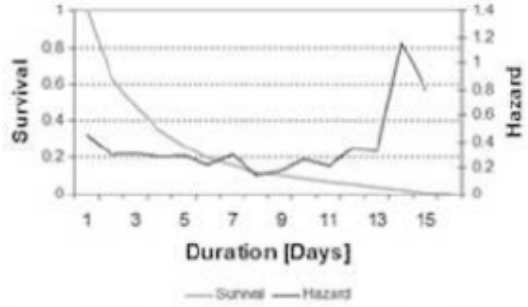
Club meeting



Active sports

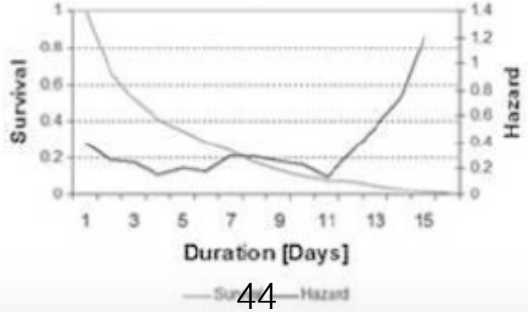


Meeting family or friends



Going for a stroll

Going out (bar, restaurant, cinema)



Axhausen et al, 2010

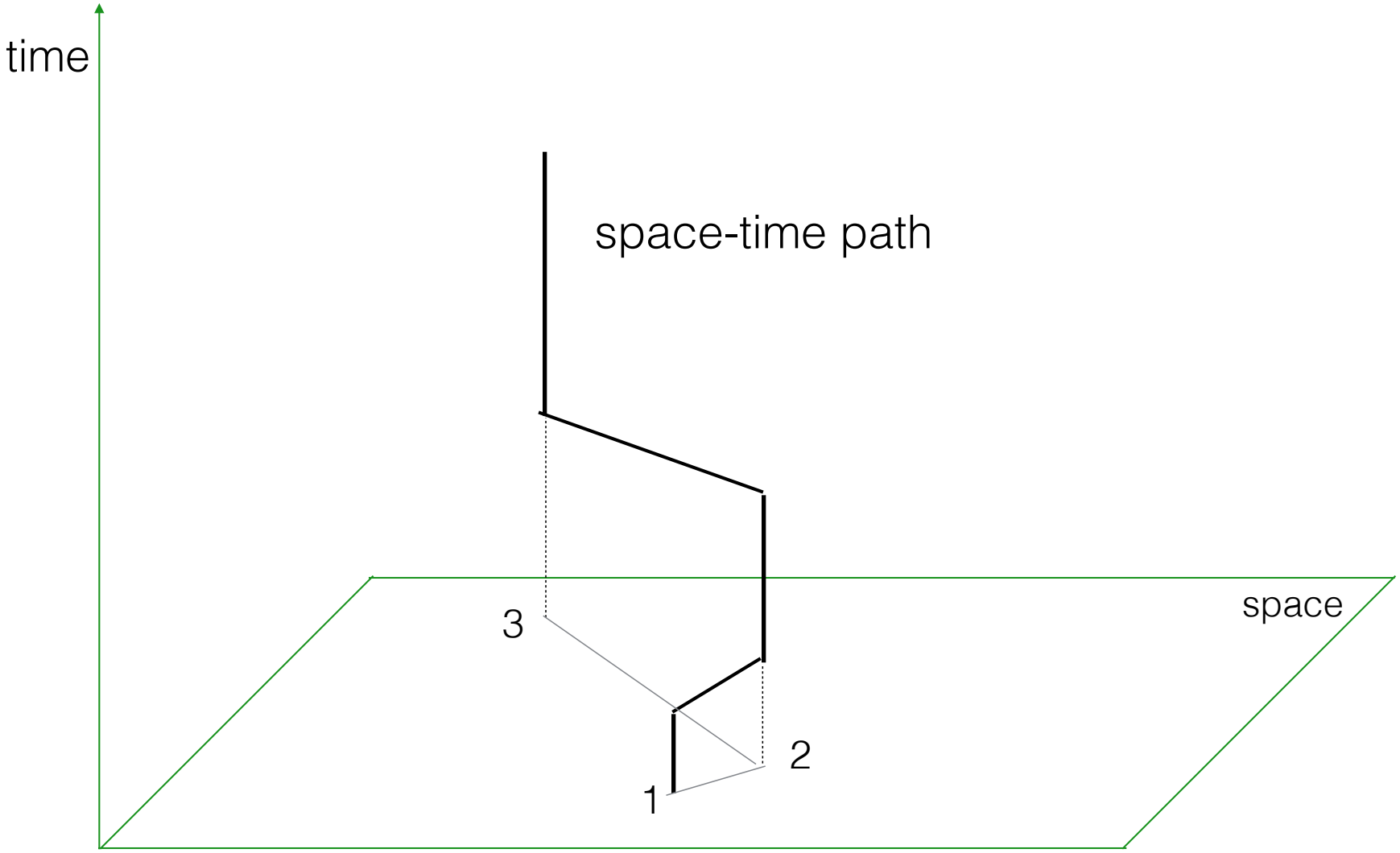
Activity type / Covariate	Daily shopping	Long-term shopping	Private business	Meet family/ friends	Club meeting	Active sports	Excursion into nature	Going for a stroll	Going out (bar, restaurant, etc.)
Personal information									
Male					+		+		
Age							-	+	+
Age^2				+			+		-
Married / cohabiting	-								-
Parent	-	-	-	+	+			-	
Club member	+					-			
Dog owner	-		+					-	
Works full time	+	+			-		-	+	
Household									
N household members		+	+			+	+		+
High income	-		-			+	+	-	
Car availability									
Number of vehicles		+				+			
Main car user				-	-	-			-
Type of area									
Karlsruhe								+	
McFadden's rho[1]	0.01	0.00	0.01	0.02	0.02	0.03	0.08	0.12	0.02

2ce0b5d7a75bc2e2d9fc97a4dca29a9
ebra

Axhausen et al, 2010

Spatial behaviors

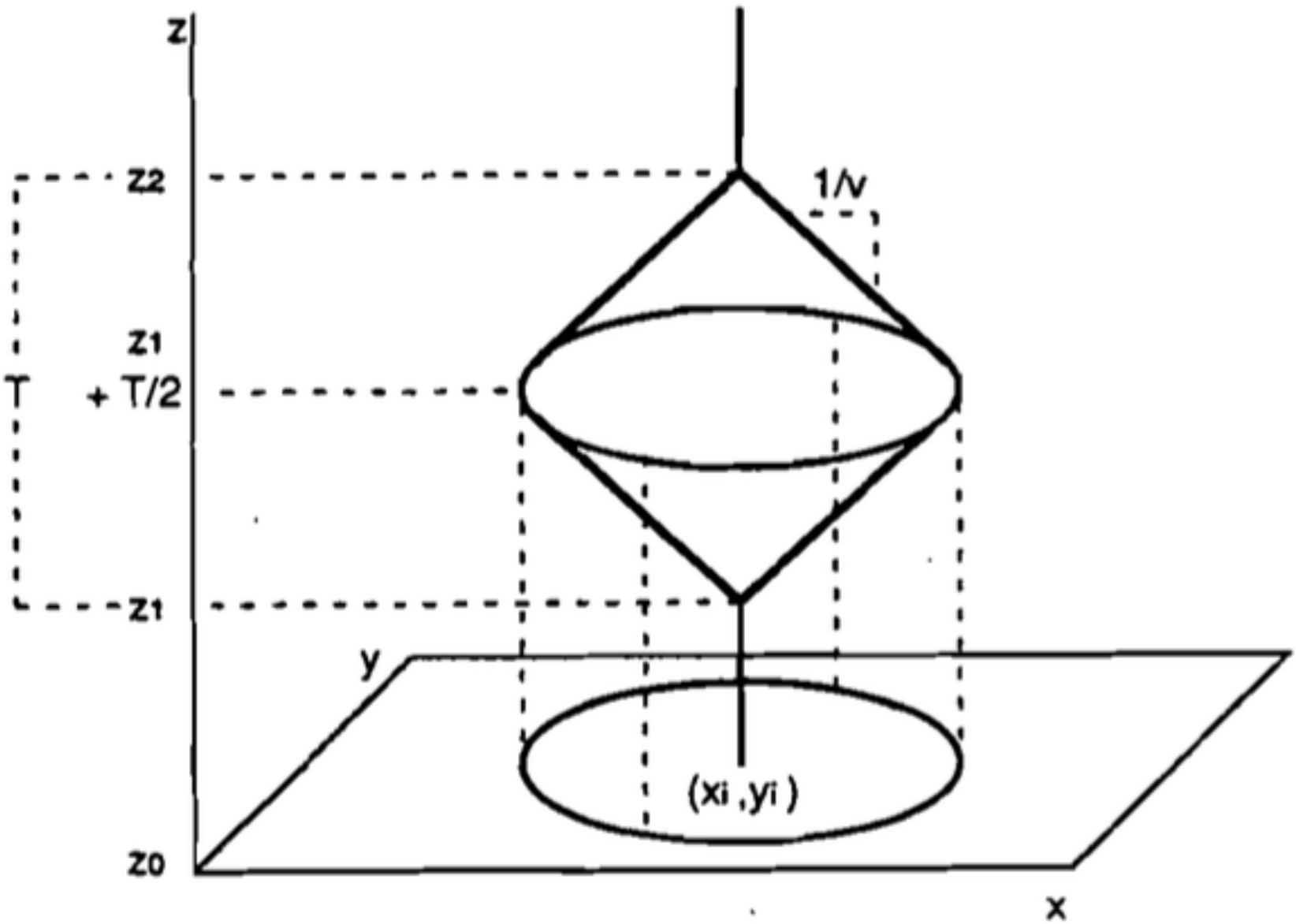
- destination choices, and
- the broader spatial opportunities

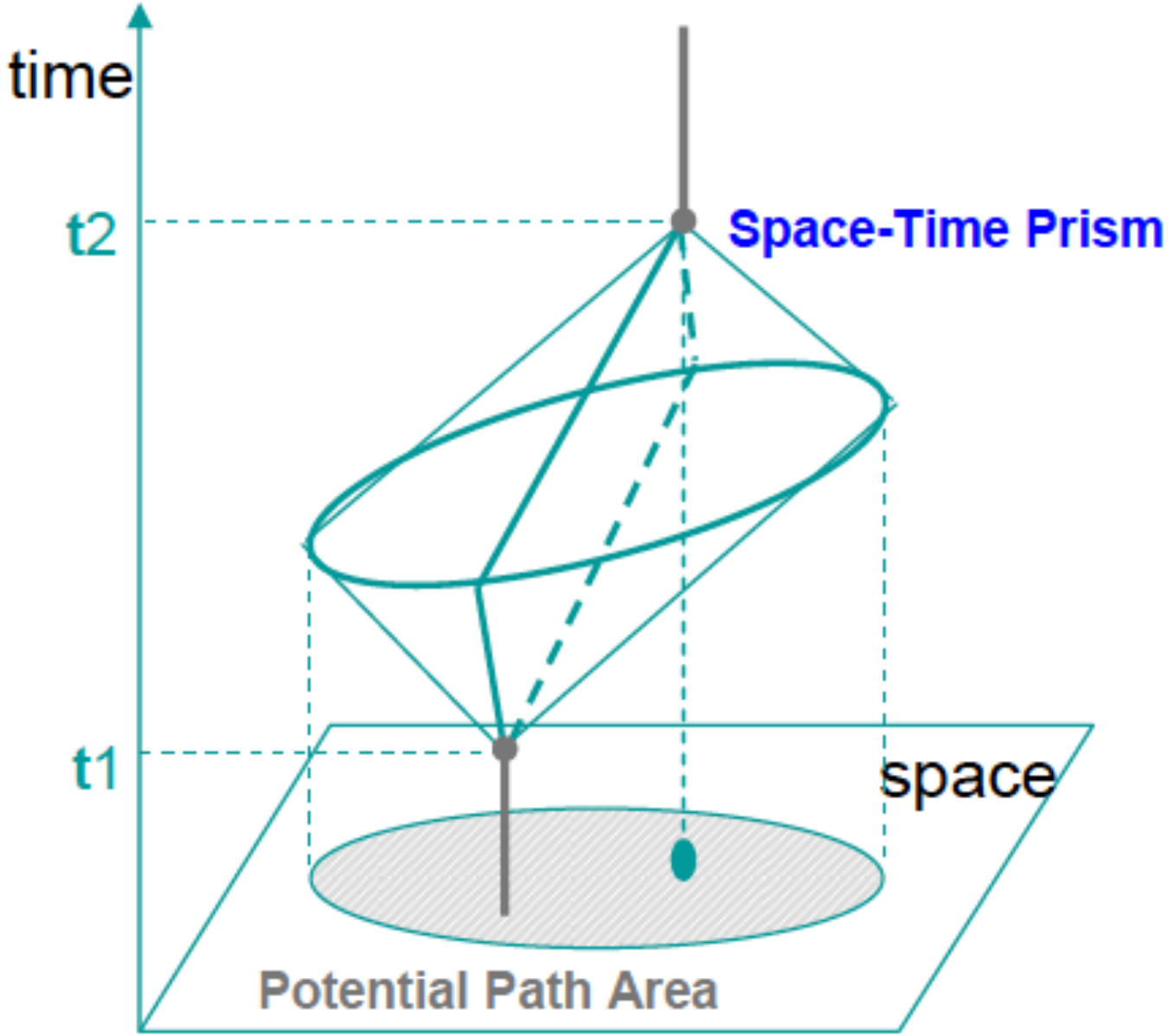


Hagerstrand, 1982

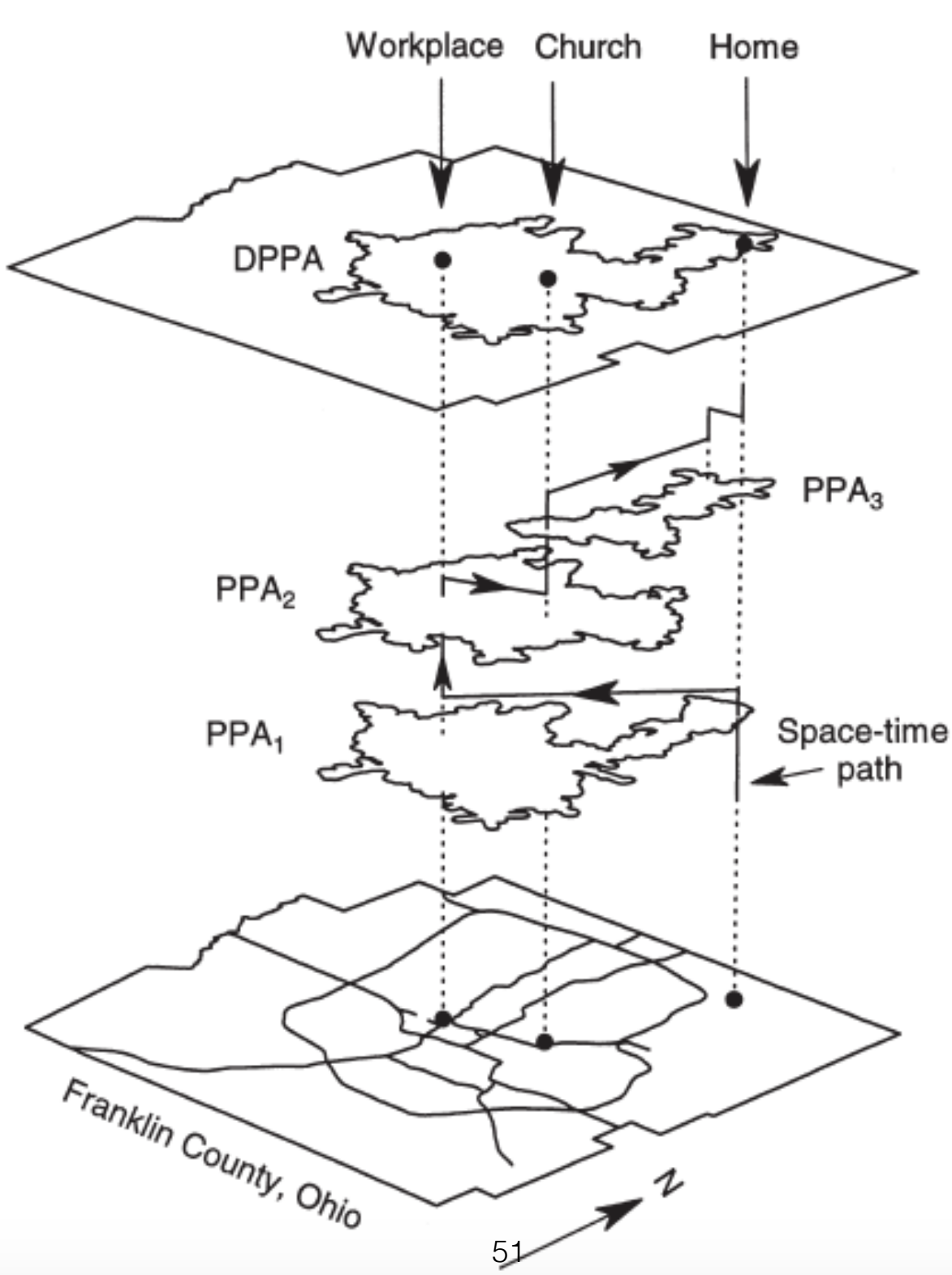
Hagerstrand's 3 constraints

- capacity
- coupling
- authority


z
z2
1/v
z1
T
+ T/2
z1
y
(xi ,yi)
z0
x



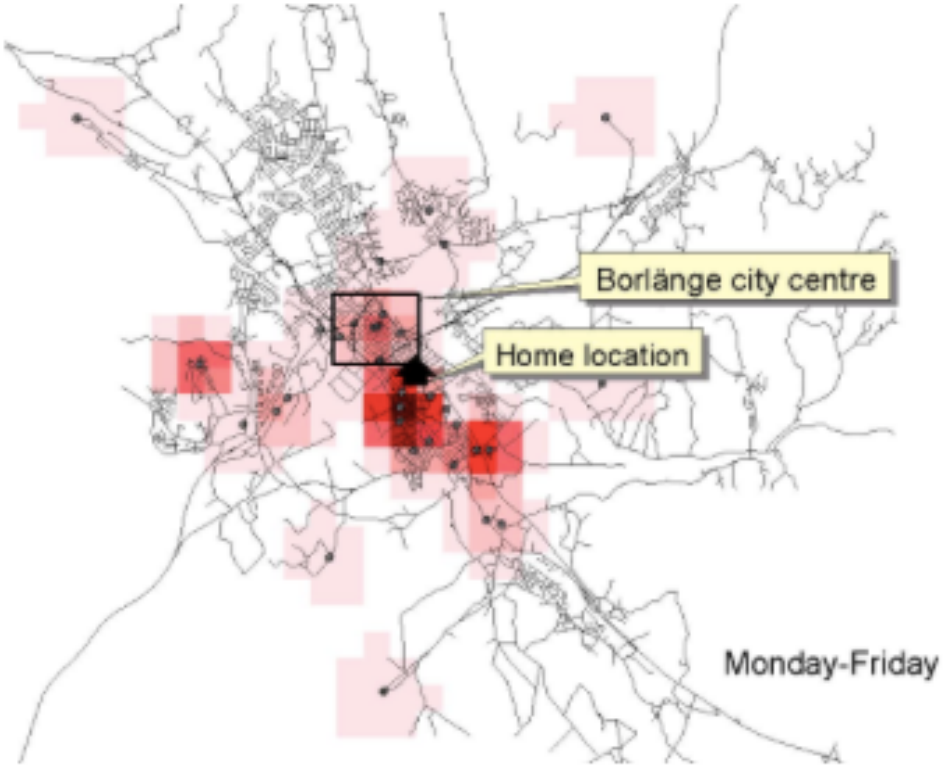
Hagerstrand, 1982

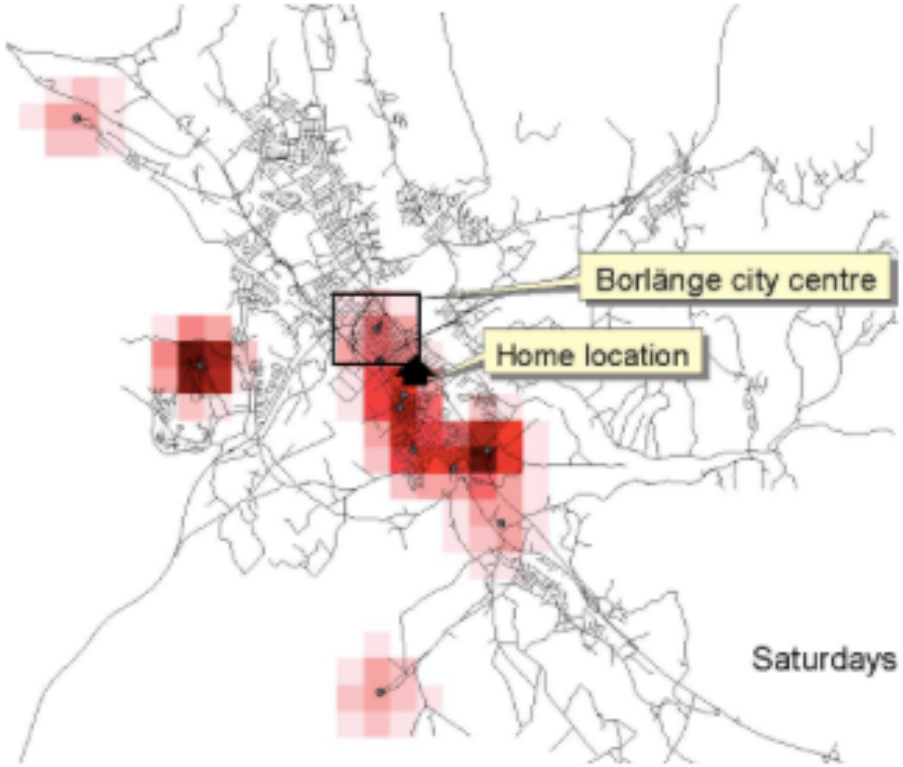

Workplace
Church
Home
DPPA
PPA3
PPA2
PPA1
Space-time path
Franklin County, Ohio
N

Kwan, 1999

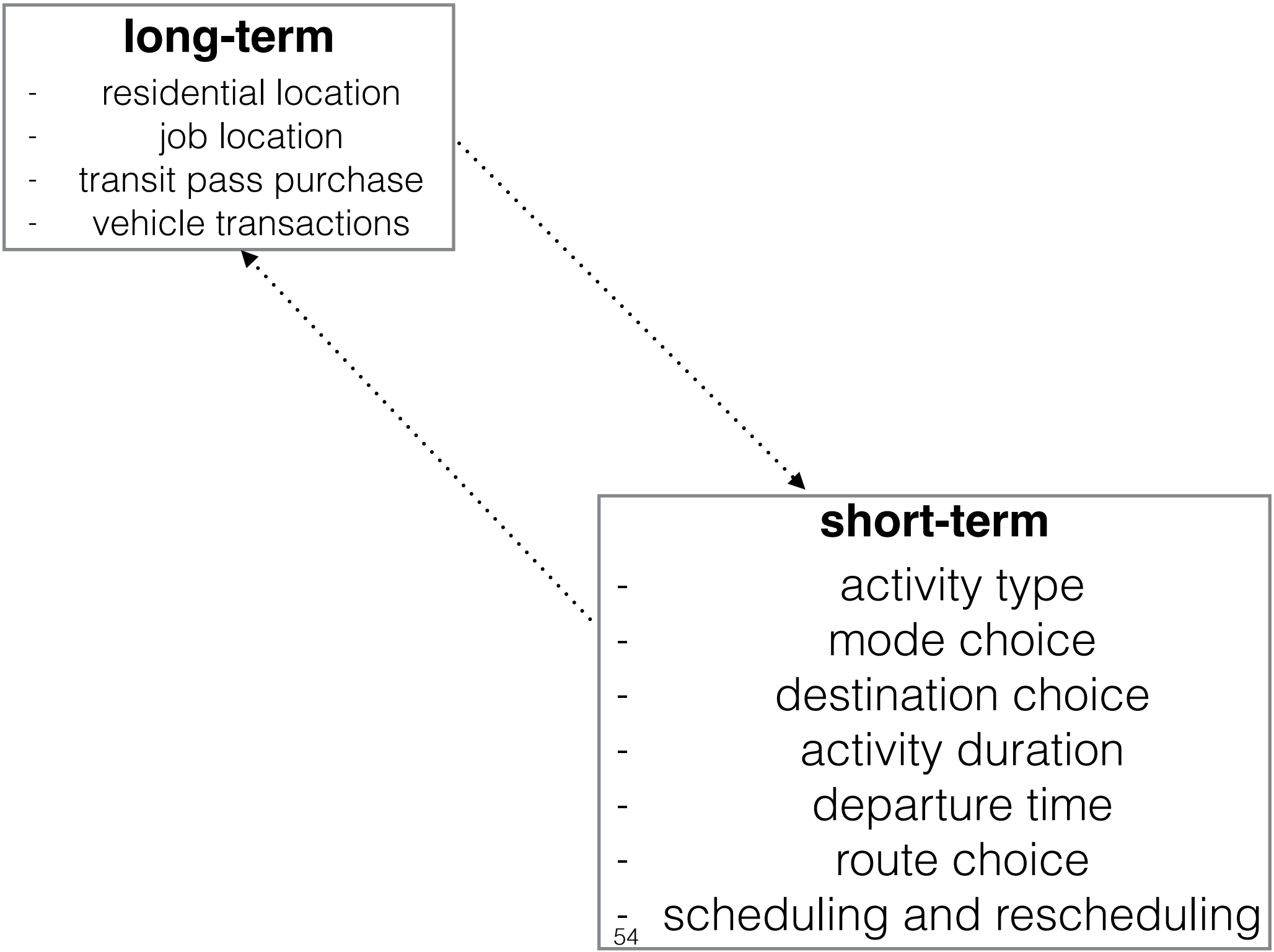
71
270
N
Fixed Locations
Home
Work
Church
Network arcs in DPPA
2 0 2 Miles

Kwan, 1999



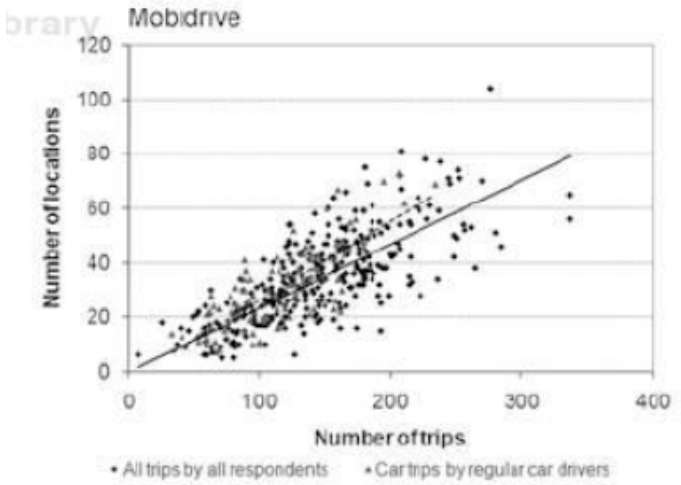


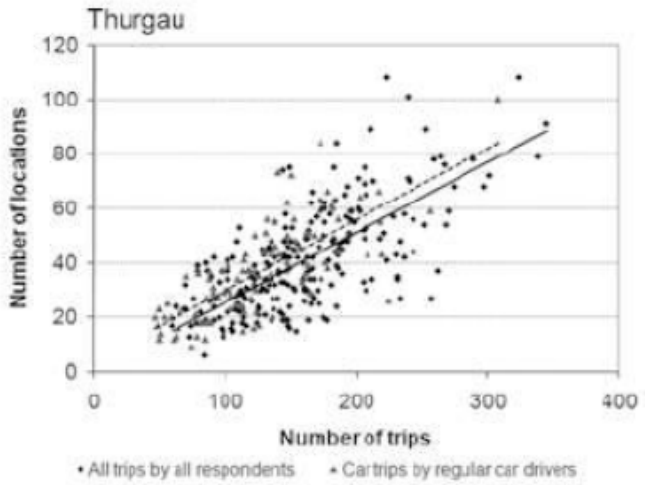
Schonfelder, 2006

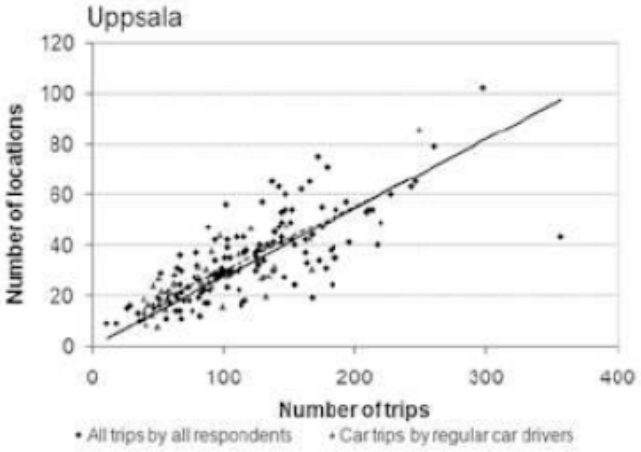

long-term
- residential location
- job location
- transit pass purchase
- vehicle transactions
short-term
- activity type
- mode choice
- destination choice
- activity duration
- departure time
- route choice
- scheduling and rescheduling

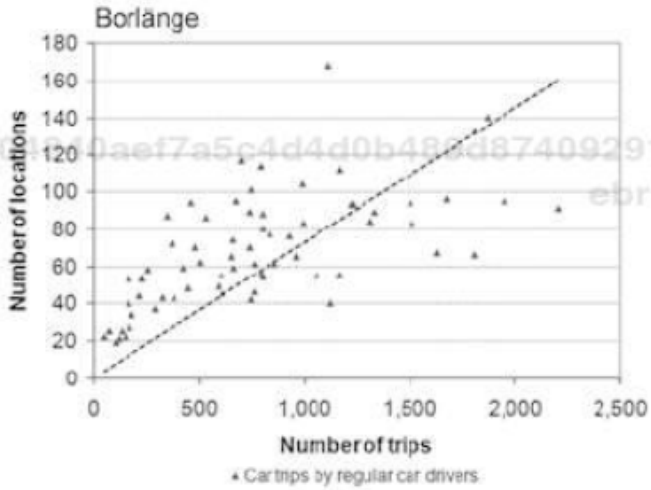
Measurement of human activity space

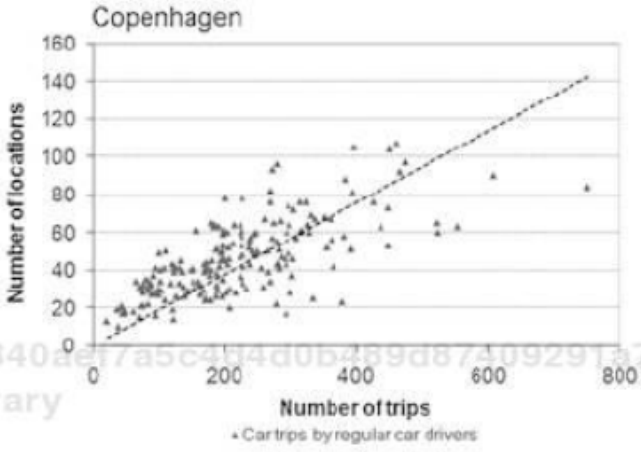
- enumeration of trips and/or unique locations
- continuous representation of use of spaces

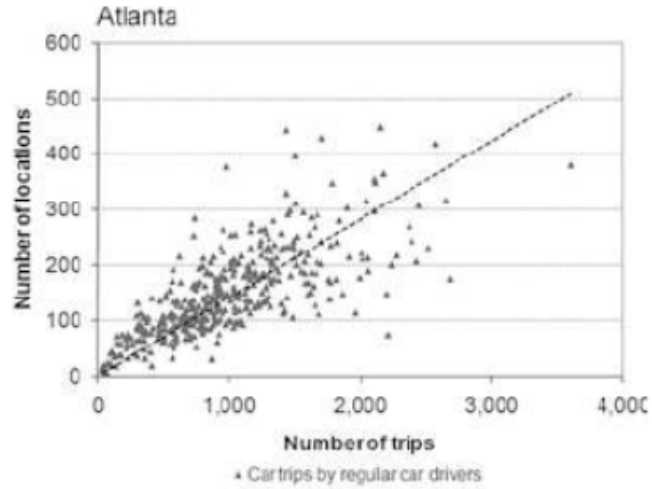






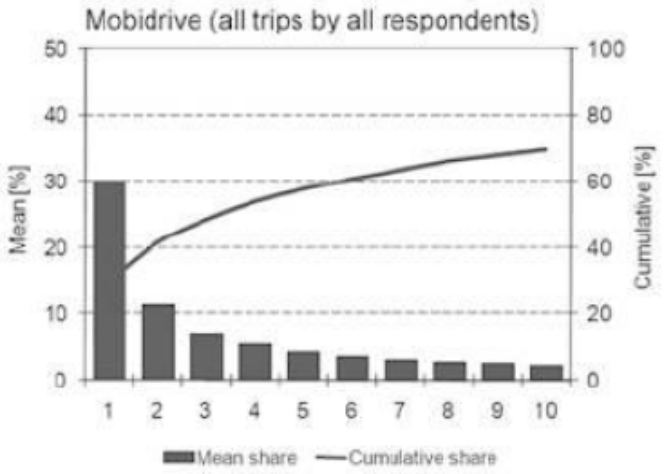


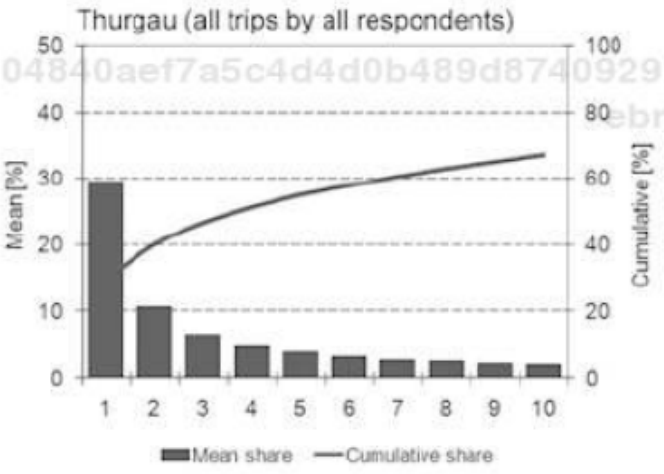


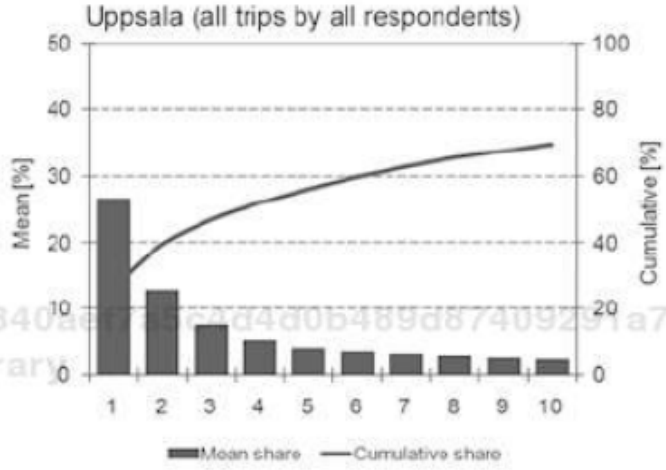


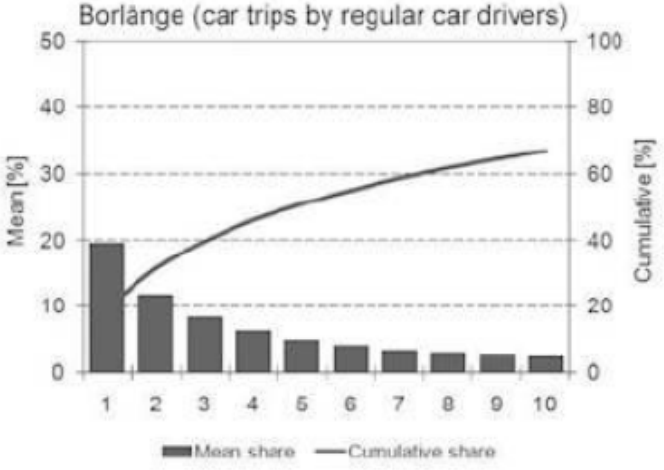
Schonfelder and Axhausen, 2010

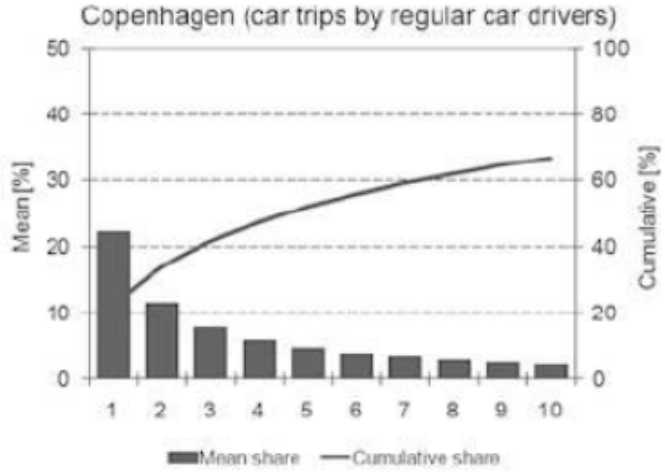
Mean shares of trips to 10 most frequently visited locations

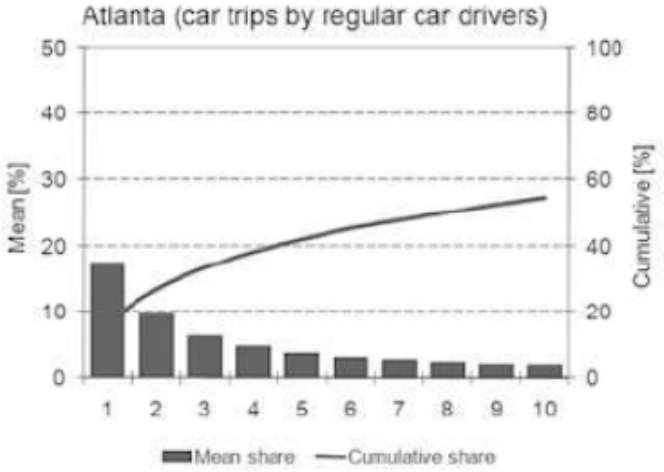






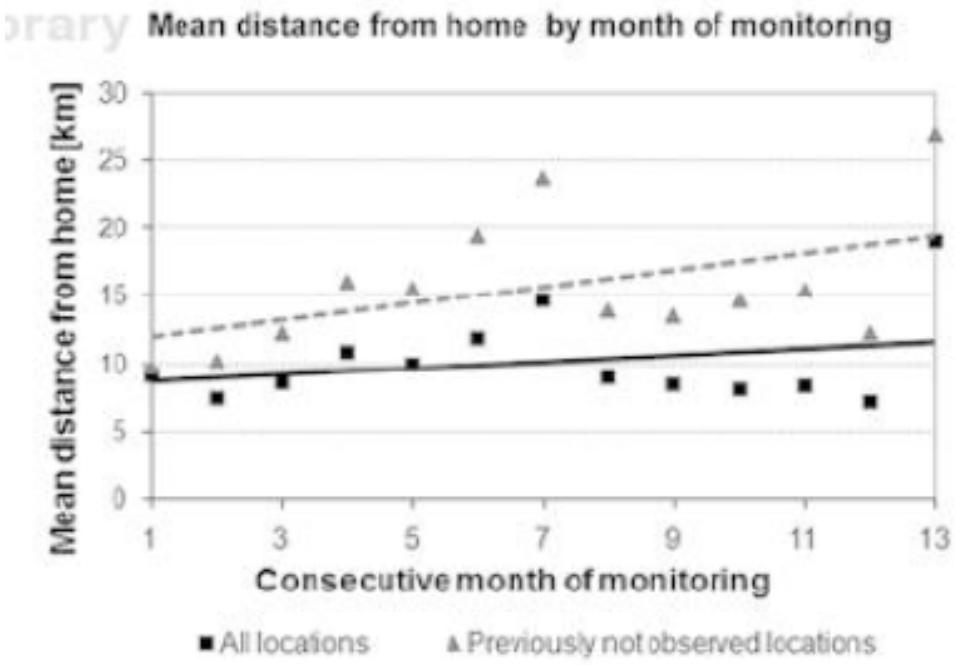


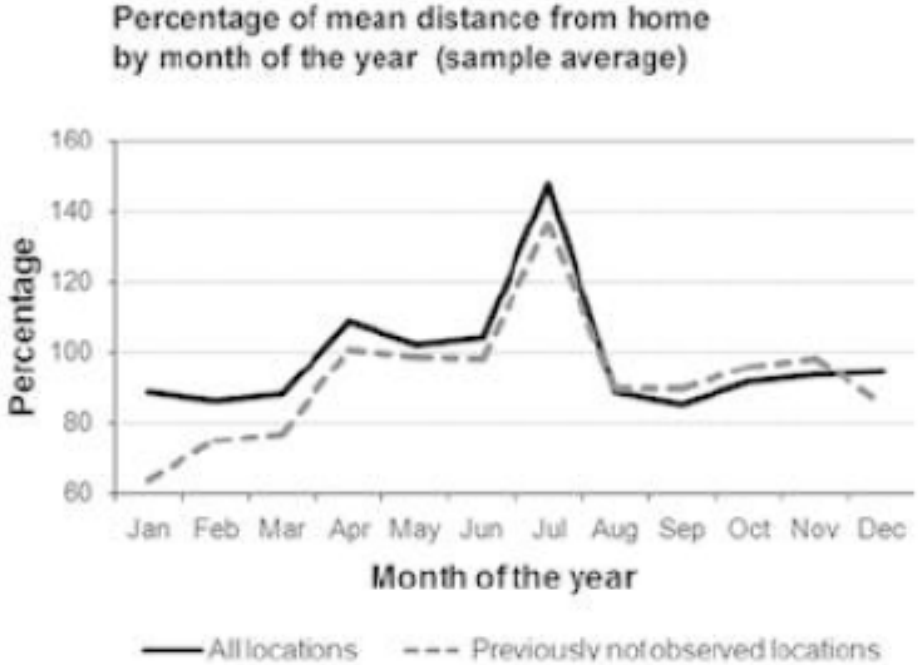




Schonfelder and Axhausen, 2010

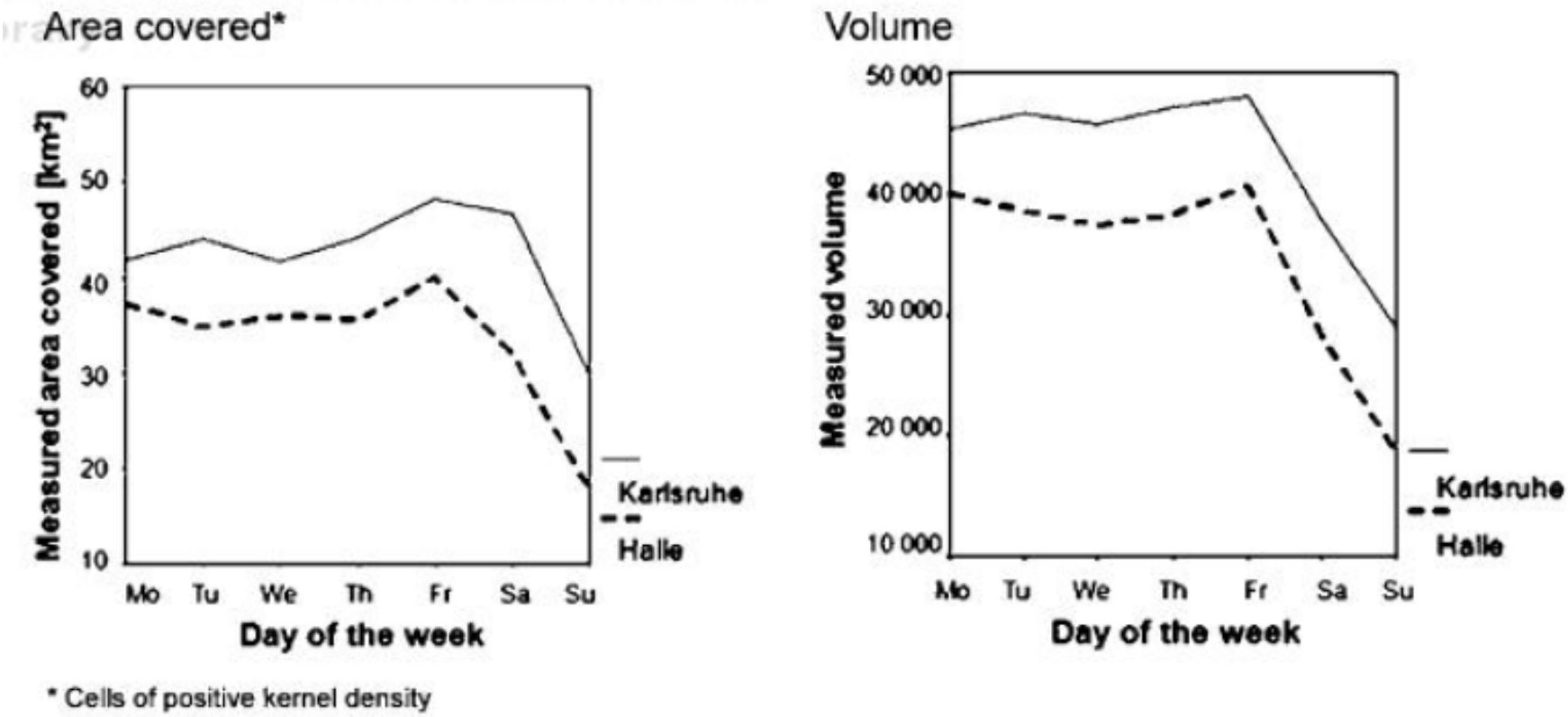
Dispersion of locations visited



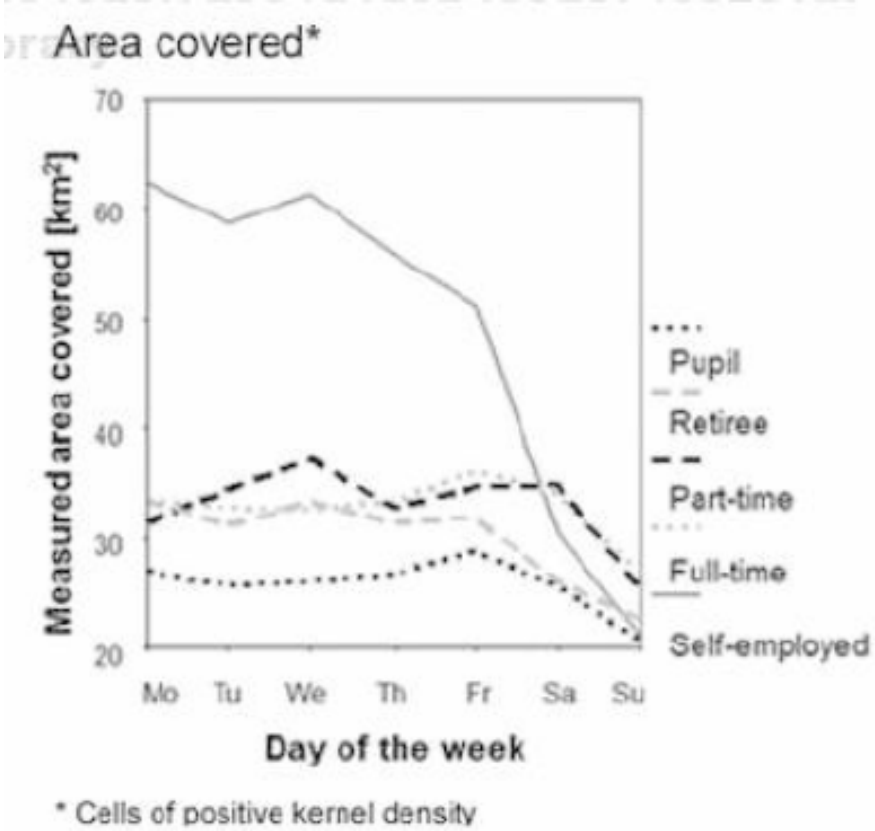


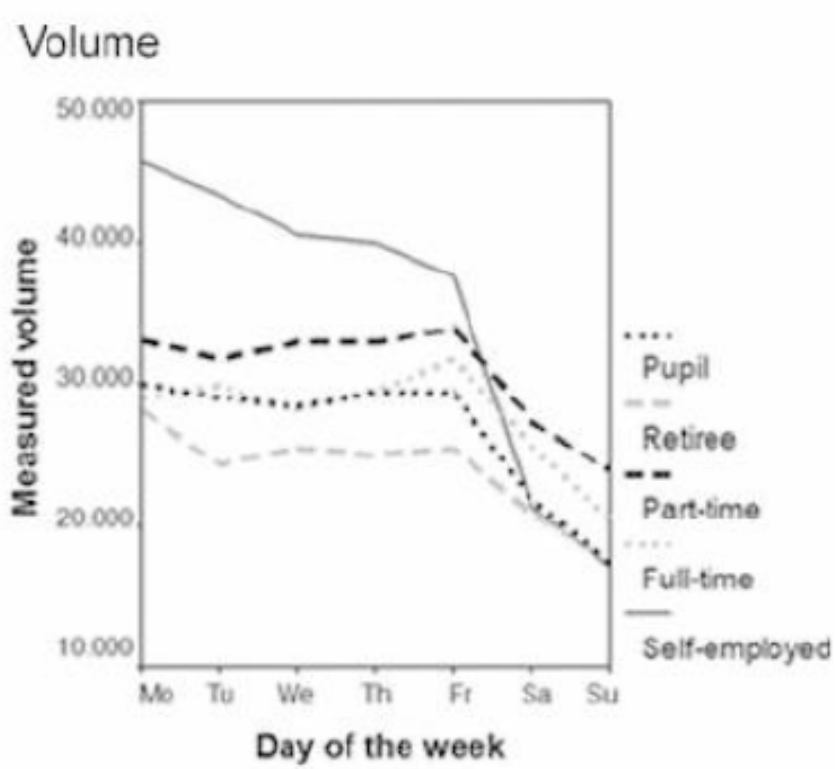
Schonfelder and Axhausen, 2010

Kernel densities by day of the week



Schonfelder and Axhausen, 2010





Schonfelder and Axhausen, 2010