Population-wide social network dynamics with life-cycle events: modeling approach and first analyses

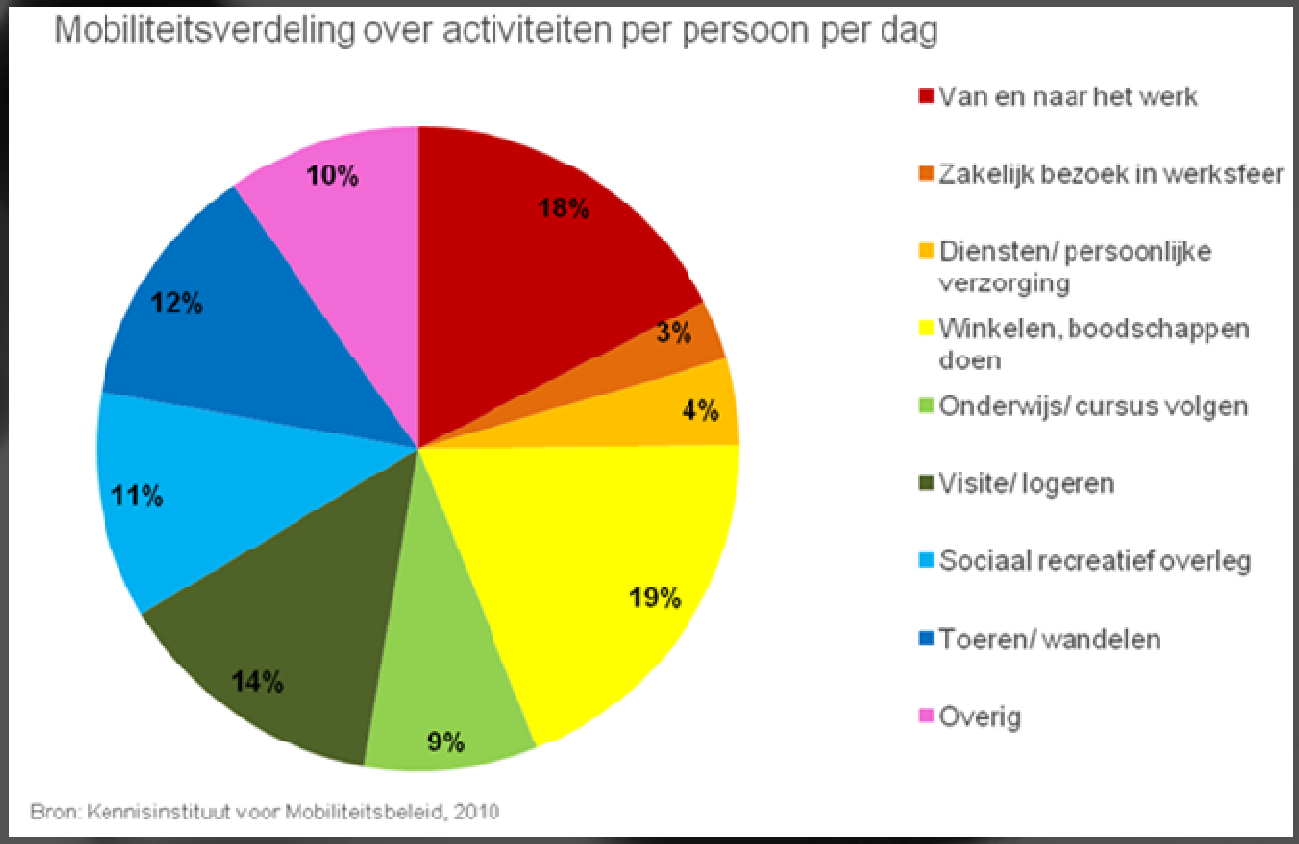
Fariya Sharmeen, Theo Arentze, Harry Timmermans

TU/e Technische Universiteit Eindhoven University of Technology
Where innovation starts
European Research Council
erc
EURATOM

Background

- Large scale micro simulation models for travel demand prediction
- Extensive modeling of mandatory and maintenance trips
- Limited attention to social and leisure travel
- Representation of social network is still scarce

Background


Mobiliteitsverdeling over activiteiten per persoon per dag
18%
3%
4%
19%
9%
14%
11%
12%
10%
Van en naar het werk
Zakelijk bezoek in werksfeer
Diensten/ persoonlijke verzorging
Winkelen, boodschappen doen
Onderwijs/ cursus volgen
Visite/ logeren
Sociaal recreatief overleg
Toeren/ wandelen
Overig
Bron: Kennisinstituut voor Mobiliteitsbeleid, 2010

Background

- Increasing amount of social and leisure trips
- Netherlands:
  - 15% of trips for social visits
  - 20% of total passenger volume for social visits
- Travel choices influenced by travel parties
- Social network is dynamic
- Changes with life cycle events

Review: examples

- Studies related to social network and social travel simulation
  - Hackney and Axhausen, 2006, Marchal and Nagel, 2006,
  - Illenberger, Flotterod and Nagel 2009
  - Arentze, van der Berg and Timmermans, 2012
  - Arentze, Kowald and Axhausen 2012
  - Kowald, Arentze and Axhausen, 2012
- Studies related to negotiation protocols
  - Ma, Ronald, Arentze and Timmermans, 2011
  - Ronald, Arentze and Timmermans 2011, 2012

Contribution

- Arentze, van der Berg, Timmermans 2012:
  - Utility based link formation model
  - A method of social network microsimulation
- Arentze, Kowald, Axhausen 2013:
  - Extension including transitivity
- This study:
  - Extension to incorporate long term dynamics
  - Life cycle events

Link selection model

$$U_{ij} = V_{ij}^{Q} + V_{ij}^{D} + V_{ij}^{C} + \varepsilon_{ij}$$

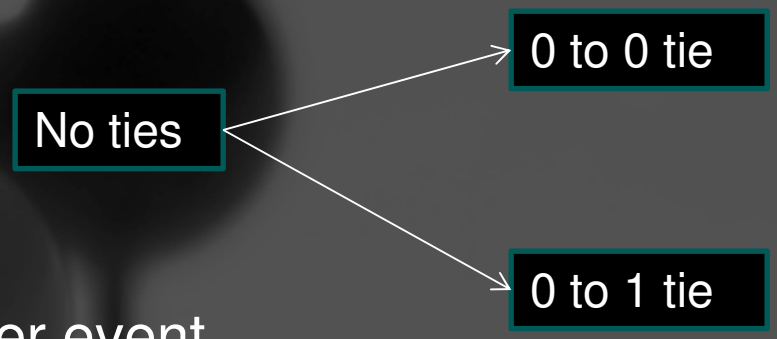
$$U_{ij} = U_{ji}$$

$$P(i \leftrightarrow j) = \Pr(U_{ij} > \max[u_{ij}, u_{ji}])$$

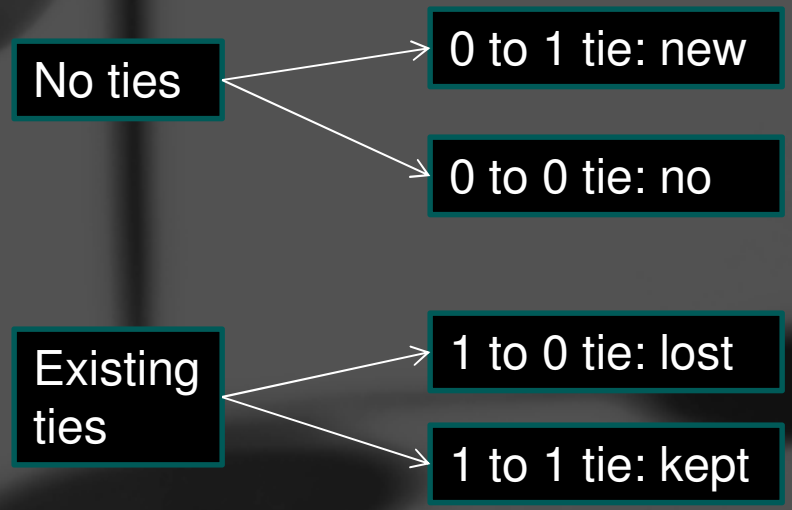
$$u_{ij} = \begin{cases} u_i^0, \text{ if } C_{ij} = 0 \\ u_i^0 - \theta, \text{ otherwise} \end{cases}$$

Concept

Before event



After event



Dataset 1

- Tool: Event based retrospective survey
- Where: Netherlands
- When: Fall 2011
- How Many: 703 respondents, representative sample from a dedicated panel and University students
- Medium: Web, pen and paper

Dataset 1

- Pre-selection based on life cycle events
- Which events?
  1. Residential relocation
  2. Starting new job
  3. Starting University
  4. Children starting school
  5. Getting married/cohabitation /divorced/separated

Events affecting geographical distance with alters

Events affecting mandatory activity-travel

Events affecting maintenance activity-travel

Demographic events

Dataset 1

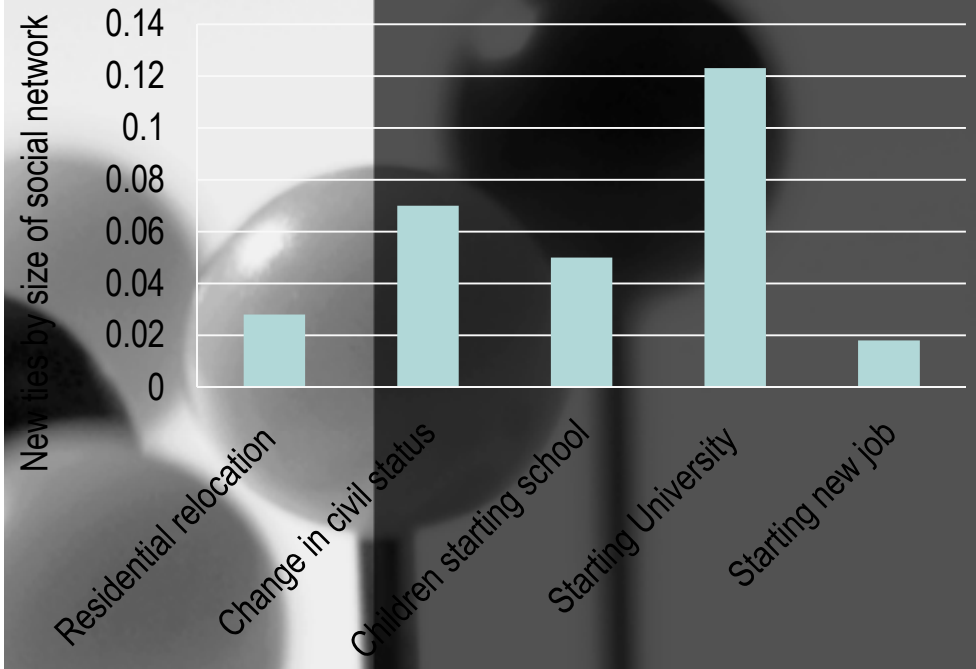
4 parts

1. Socio demographics
2. Present social network
3. Social network dynamics
4. Activity and travel behavior dynamics

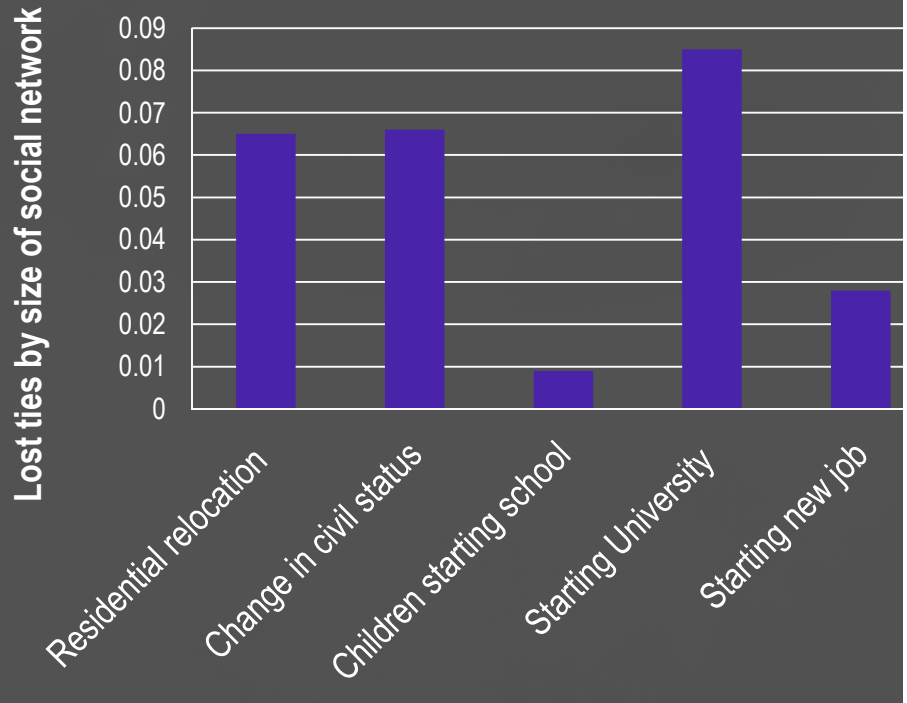
Data descriptives

Observed Variables	Description	Mean or Proportion
Age <=20	Age of ego is less than 20 years: Young	17.2%
Age 21-40	Age of ego is between 21 to 40 years: Young adults	60.3%
Age 60+	Age of ego is more than 60 years: Seniors	8.4%
Male	Ego is male	55.1%
Highedu	Ego's highest achieved level of education is undergraduate or higher	67.4%
#workhr	Number of working hours per week	21.60
#child	Number of child in the household	0.97
Driving License	Having car in the household and the ego has driving license	79.6%
SNSize	Size of close social network	29.02
Ch home location	Ego changed home location in past 2 years	18.9%
Ch civil status	Ego started living together or got married or separated or divorced in past 2 years	19.2%
Children start sc	Children of the household (under 18) started school	21.8%
Start university	Ego joined University for higher education	21.4%
Start new Job	Ego started a new job	18.7%
# Lost ties	Number of ties lost after the event	1.44
# New ties	Number of new ties after the event	1.62

Social network dynamics



New ties



Lost ties

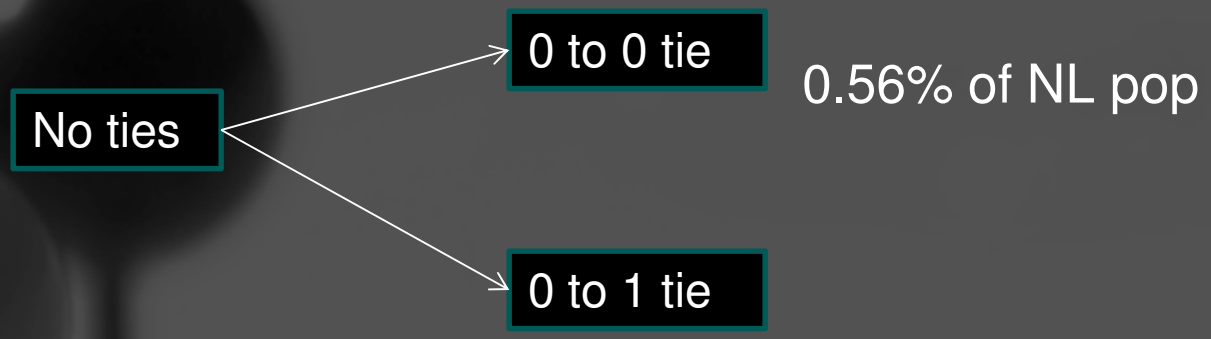
Dataset 2

National travel survey data

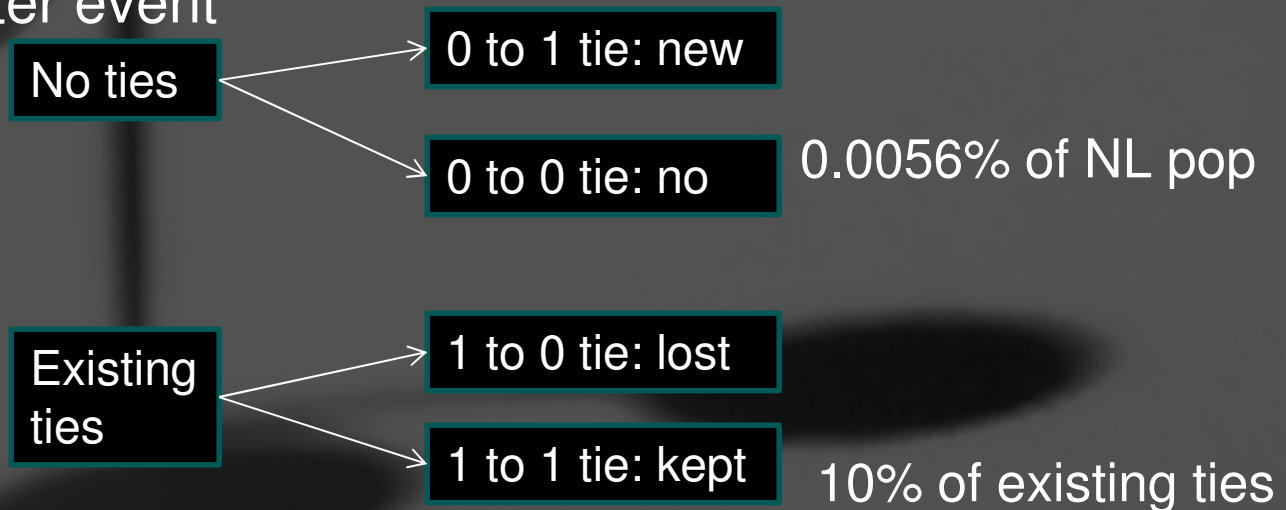
- Where: Netherlands
- When: 2009
- How Many: 33667 respondents, representative of NL population
- To draw alters (negative cases) where the tie did not exist

Sampling

Before event



After event



Sample (91278 cases)
Initial phase: before the event

Ego alter socio demographics comparison	Tie present (%)	Tie absent (%)
Same age	46.7	13.7
Different age	53.3	86.3
Age difference by 1 category	28.7	27.5
Age difference by 2 categories	11.1	23.4
Age difference by 3 or more categories	13.5	35.4
Same gender	62.8	49.8
Different gender	37.2	50.2
Same education level	12.6	9.2
Different education level	87.4	90.8
Education level difference of 1 category	33.6	16.4
Education level difference of 2 categories	16.8	14.3
Education level difference of 3 or more categories	37.0	60.1
Distance (mean) in km	38.4	133.207

Sample (2108 cases)
Adaptation phase: after the event

Ego alter socio demographics comparison	Tie present (%)	Tie absent (%)
Same age	63.6	20.7
Different age	36.4	79.3
Age difference by 1 category	24.6	37.9
Age difference by 2 categories	7.7	24.9
Age difference by 3 or more categories	4.1	16.5
Same gender	65.4	49.2
Different gender	34.6	50.8
Same education level	12.8	11.6
Different education level	87.2	90.8
Education level difference of 1 category	35.8	25.2
Education level difference of 2 categories	16.3	27.4
Education level difference of 3 or more categories	35.1	38.2
Distance (mean) in km	26.829	125.354

Approach

Merge and create a dataset with two phase: initial and adaptation phase

Create the phase and interaction variables

Correcting for between effects: panel structure…random effects

Correcting for separate groups of observation: scale parameter

Results: Binary Scaled Mixed Logit Model

Homophily between ego and alter	Ties present or not Dependent var tie =prsent	
	β1	t
Constant	-2.26	-31.35
Same age group	1.36	32.30
Age diff 2 categories	-0.585	-11.54
Age diff 3 categories	-0.633	-10.91
Age diff 4 or + categories	-0.912	-11.21
Same gender	0.684	18.05
Same education level	0.130	2.42
Education level diff 2 cat	-0.029	-0.59
Education level diff 3 or +cat	-0.311	-7.43
Log of distance (before event)	-3.22	-82.59

Results: Binary Scaled Mixed Logit Model

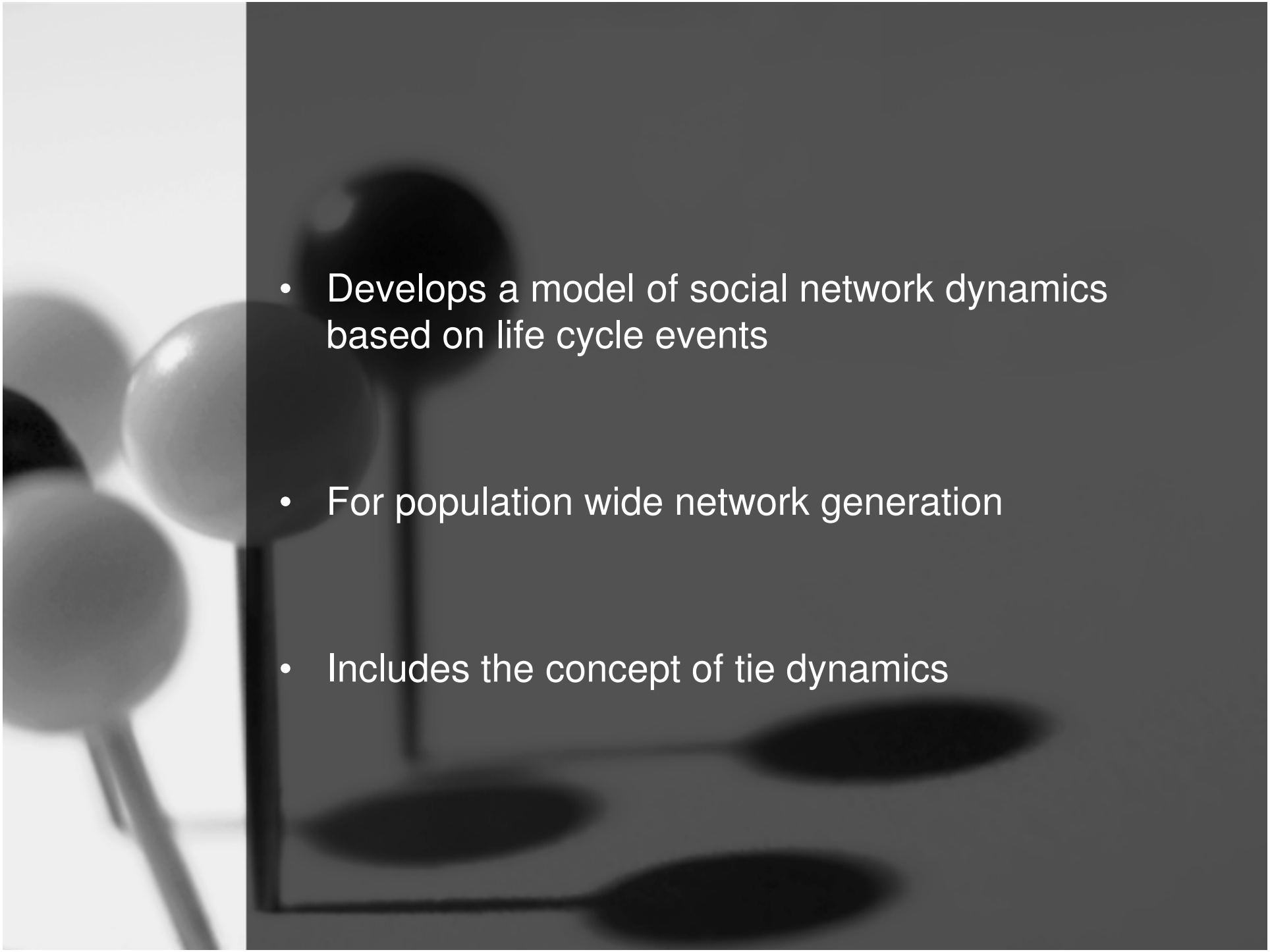
Explanatory variables	Ties present or not Dependent var tie =prsent	
	β1	t
Constant * adaptation phase	3.11	1.58
History of tie(yes)	9.73	11.03
Event: residential relocation	2.14	4.44
Event: change in work/study hr	2.91	5.21
Event: children start school	2.37	3.53
Size of social network	-0.243	-9.81
# of club membership	0.031	1.71

Results: Binary Scaled Mixed Logit Model

Random and scale effects	Ties present or not Dependent var tie =prsent	
	β1	t
Std deviation random effects		
Constant	2.09	42.62
Distance	0.495	24.43
Same age group	0.503	7.16
Same gender	0.502	7.15
Scale parameter: adaptation phase	0.806	2.34

Model fitting information:

Init log-likelihood: -63935.896
Final log-likelihood: -17596.653
Rho-square: 0.725
Adjusted rho-square: 0.724



- Develops a model of social network dynamics based on life cycle events
- For population wide network generation
- Includes the concept of tie dynamics

Application

- Generate a social network in initial phase
- Predict adaptation behavior and updated social network with life cycle events
- Dynamic travel behavior modeling

Work in progress

- Sensitivity test
- Urban density effects
- Model selection test
- Micro simulation

Thank You

Questions?

Fariya Sharmeen
f.sharmeen@tue.nl