Induced demand:
Dutch evidence and models

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Outline of the talk

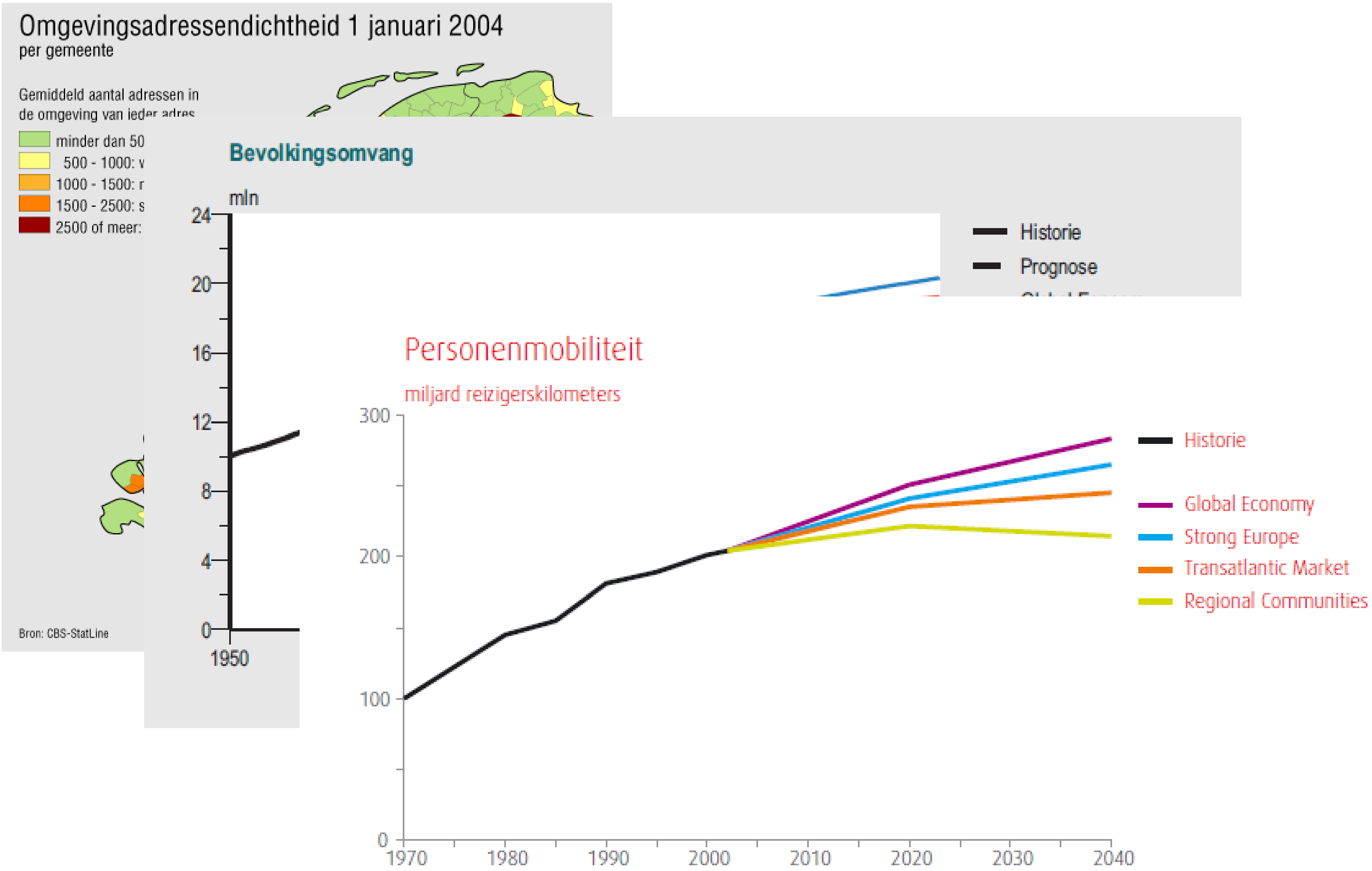
- **Dutch evidence – empirical perspective**
  - **Spatial - policy context**
  - **The influence of built environment**
  - **Response to pricing policies**

- **Models – theoretical perspective**
  - **Activity generation - conceptual developments**
  - **Travel choices - multistate supernetwork approach**

Dutch evidence

Empirical perspective

Netherlands – urban density and population



Netherlands – characteristics (Maat et al. 2008)

- **Compact neighborhoods and city centers**
- **Many facilities for bicycle use**
- **Large-scale out of town shopping centers are discouraged**
- **Ratio of cars per 1,000 inhabitants is relatively low (427) compared to Belgium (464), Germany (546) and UK (466)**
- **22 % of the households own 2 cars and 2.3 % more than 2 cars**
- **Public transport only 5 % of trips**

Netherlands – spatial policy

- **Urban and transport planning has long tradition**
- **Since 80's policy aimed at reducing growth car use**
  - **Compact city**
  - **City designs with high density and mixed land-use**
- **Recent years, national policy**
  - **Urban networks concept with more emphasis on facilitating travel rather than reducing it**
  - **Accommodating growth in existing built environment**
- **All in all a consistent focus on concentrated urban development (Wee and Maat, 2004)**

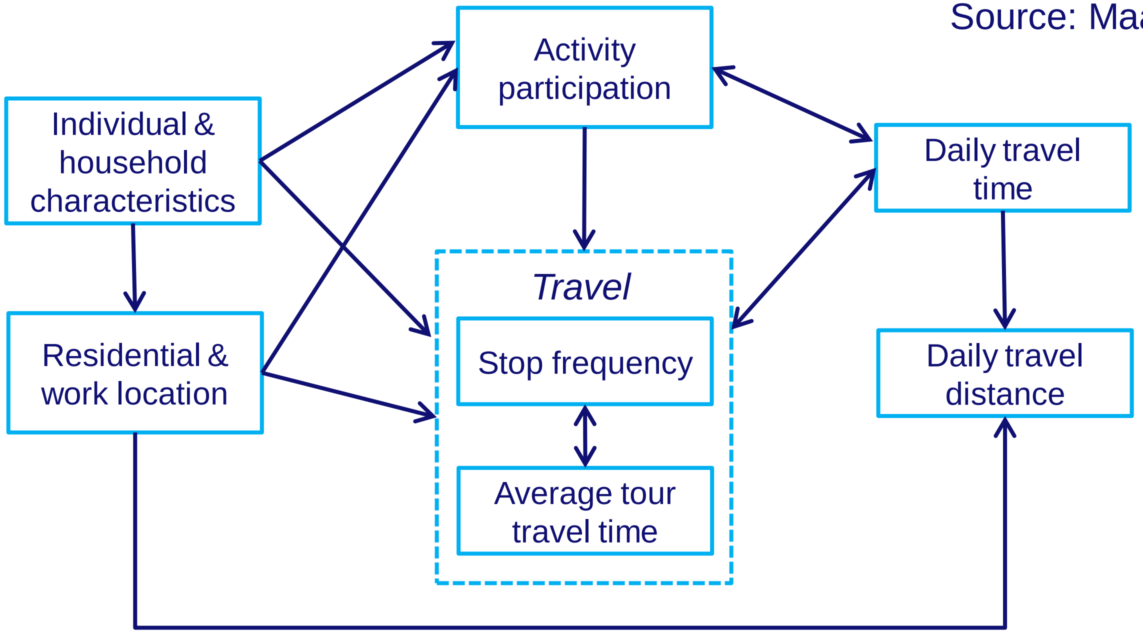
Influence of built environment

- **Study by Maat (2008) is very comprehensive**
  - **Uses activity diaries of a large sample of households**
  - **Sample is stratified on density and accessibility of public transport**
  - **Accounts for an extensive set of spatial variables**
    - **Mixed land-use (employment and retailing)**
    - **Urban density**
    - **At residential AND work location**
  - **Structural equation modeling is used to account for direct and indirect effects**

- **Findings are largely consistent with other Dutch studies** (e.g., Schwanen et al. 2004; Snellen and Hilbers 2007)

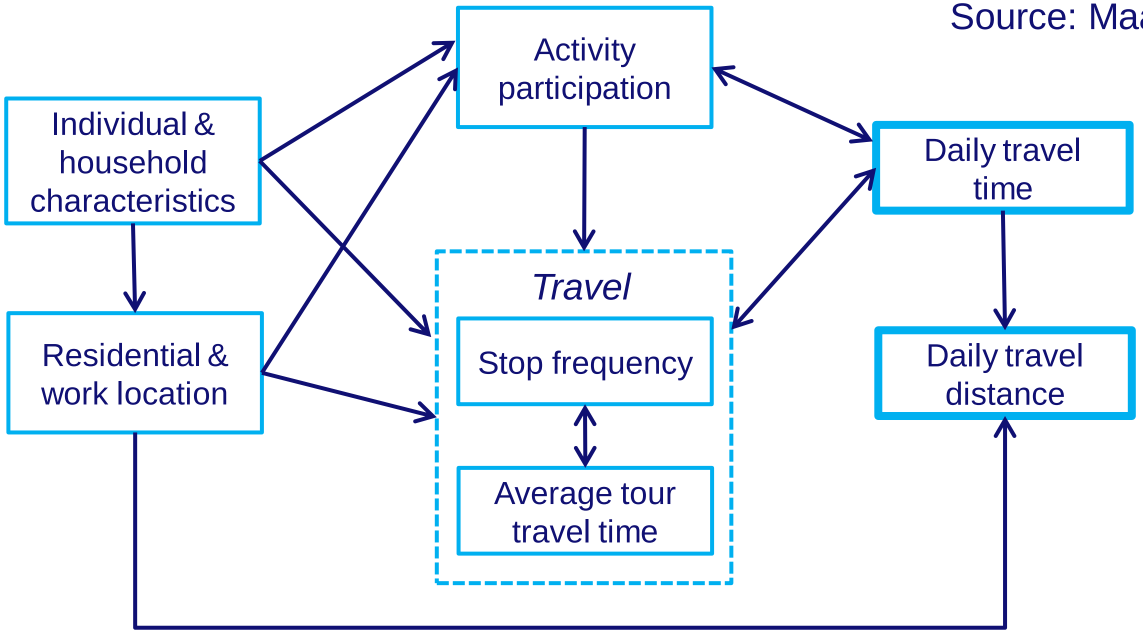
Conceptual scheme

Source: Maat and Timmermans (2007)



Some findings

Source: Maat and Timmermans (2007)

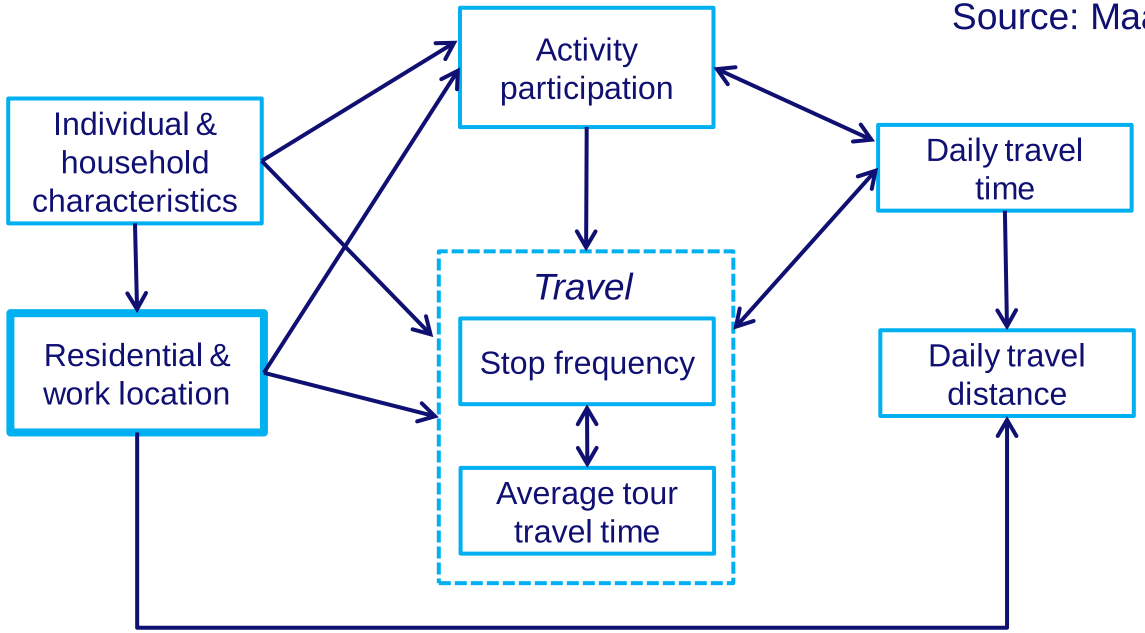


Travel distance / time

- **Predominantly explained by activity participation**
- **Only small direct effects from household characteristics**
- **Urban from has an impact, but impact is small**

Some findings

Source: Maat and Timmermans (2007)

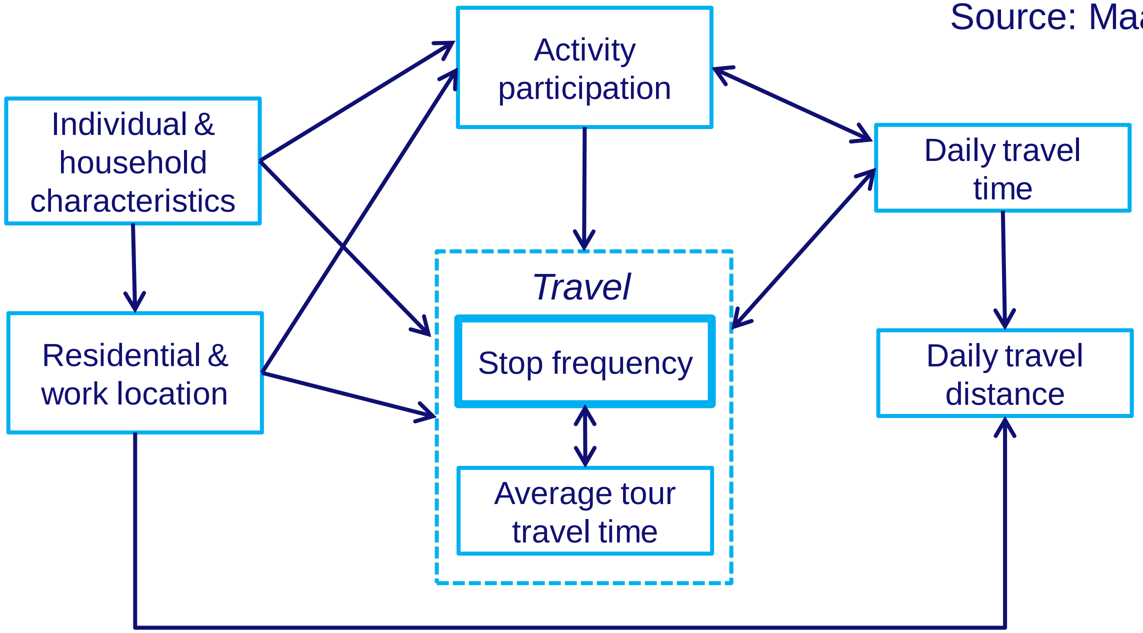


- High residential density
  - Extra activities
  - Shorter distances
  - ➢ Slightly less travel
- High density and mix at work
  - Slightly more trips
  - Shorter distance
  - ➢ Slightly less travel

- Urban form effects are largest for car travel

Some findings

Source: Maat and Timmermans (2009)

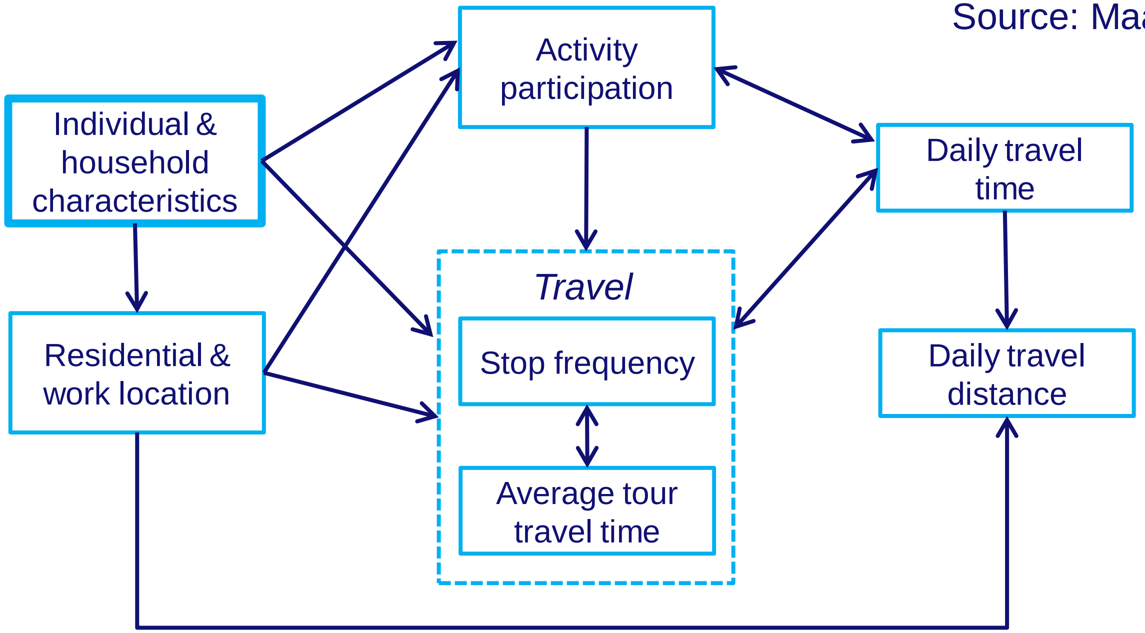


Trip chaining

- **Families with children make less complex tours**
- **High residential density leads to more trip-chaining**

Some findings

Source: Maat (2008)



Car ownership

- **High residential density reduces household car ownership**
- **High household income correlates with low residential density**
  - **This suggests that households tend to prefer low density neighborhood + car**
- **High density at work also reduces household car ownership**

Conclusions (Maat 2008)

- **High density leads to shorter travel distances, but more activities**
- **High density reduces car ownership also dependent on density of the work environment**
- **Car ownership rather than urban form is the major determinant of car use** (see also Bischoff and Kerkman 2008)
- **Separate effect of residential environment on car use is very small**
- **Work environment appears to have significant impacts on travel and mobility choices**

ALBATROSS prediction: road pricing scenario

Activity choice

	m0	m1	m1-m0 (%)	sign
Work	3948	3913	-0.89	**
Business	1331	1270	-4.59	**
Bring or get	1487	1481	-0.45	
Shop one store	4802	4760	-0.88	**
Shop multiple stores	948	938	-1.06	
Service	1112	1110	-0.17	
Social	2630	2507	-4.65	**
Leisure	2779	2697	-2.95	**
Touring	1723	1684	-2.28	**
Other	326	301	-7.48	**
Total (activities)	21086	20661	-2.02	**

Decrease of activities especially in social-leisure category

ALBATROSS prediction: road pricing scenario

Trip chaining

	m0	m1	m1-m0 (%)	sign
Single stop	13315	13121	-1.46	**
After stop	3285	3198	-2.66	**
Before stop	3285	3198	-2.66	**
Between stop	1201	1145	-4.68	**
Total (activities)	21086	20661	-2.02	**

A modest decrease of trip-chaining

ALBATROSS prediction: road pricing scenario

Activity location

	m0	m1	m1-m0 (%)	sign
home zone	6263	6372	1.73	**
home municipality	6023	6104	1.34	**
municipality order 1	2947	2760	-6.36	**
municipality order 2	2202	2066	-6.19	**
municipality order 3	1347	1250	-7.23	**
municipality order 4	1051	959	-8.69	**
municipality order 5	1228	1125	-8.38	**
Total (activities)	21086	20661	-2.02	**

A slight shift to destinations closer to home

ALBATROSS prediction: road pricing scenario

Transport mode

	m0	m1	m1-m0 (%)	sign
Car driver	8014	7270	-9.29	**
Slow mode	6284	6576	4.64	**
Public transport	587	714	21.63	**
Car passenger	1661	1706	2.71	**
Total (tours)	16600	16318	-1.70	**

A relatively big shift from car to public transport mode

ALBATROSS prediction: road pricing scenario

Mobility indicators

	m0	m1	m1-m0 (%)	sign
Total travel time (min)	504786	486323	-3.66	**
Number of tours	14905	14673	-1.56	**
Number of trips	33798	33213	-1.73	**
Ratio trips-tours	2.268	2.264	-0.18	**
Ratio single stop tours - all tours	0.803	0.806	0.29	**
Total travel distance (km)	362863	313715	-13.54	**
Distance car driver (km)	278451	218188	-21.64	**
Distance car passenger (km)	48510	53861	11.03	**
Distance slow (km)	21108	22286	5.58	**
Distance public transport (km)	14794	19381	31.01	**

A substantial decrease of car kilometers – price elasticity of roughly 0.20

Summary of findings

- Sensitivity to road price pertains to
  - Activity choice
  - Trip-chaining choice
  - Destination choice
  - Transport mode choice

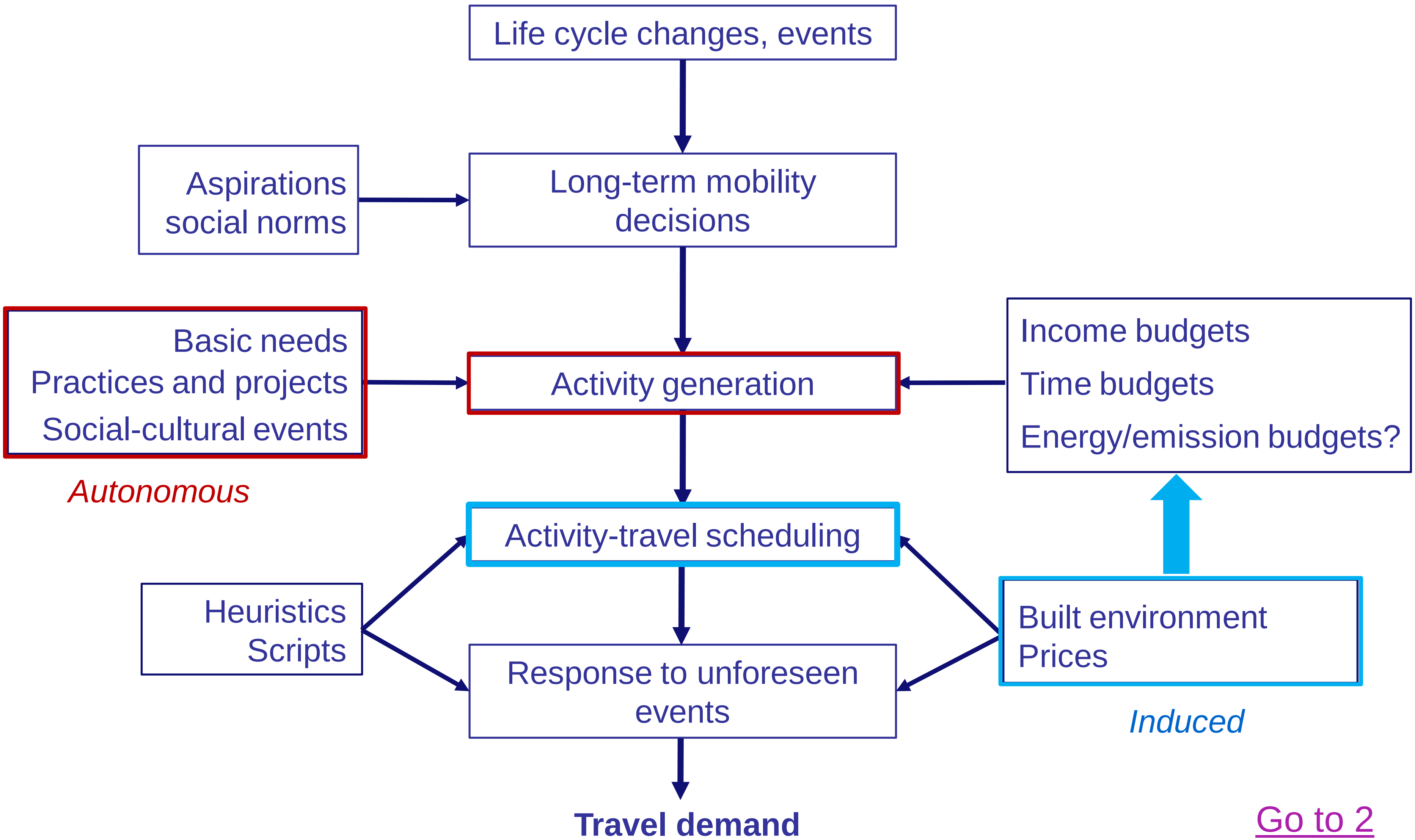
- Secondary effects are taken into acount

- Predicted price elasticity of travel demand is in line with evidence from other studies

Models

Theoretical perspective

Travel demand generation – long, mid, short term



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Activity generation

Concepts

Activity generation

- **Activity-based approach**
  - **Travel demand is induced by activities**
- **Early concepts**
  - **Households and individuals conduct activities to satisfy a set of needs within a set of constraints**
- **Annual regimes and clusters in activity sequences**
  - **Project-based theories** (Axhausen 1998, Miller 2005)
  - **Event-based theories** (Arentze and Timmermans 2009a)
- **Daily and weekly rhythms in activity-travel patterns**
  - **Need-based theories** (Arentze and Timmermans 2009b)

Projects

- A project ties together a set of activities
- Activities can only be understood in the context of a project
- An example of a project is reconstruction of one's house
- Concept is appealing but, to date not materialized in a model

Social-cultural events

- Individuals belong to a social system that is sustained through social-cultural events

- Examples of events are Birthday, Christmas, Big concert, etc.

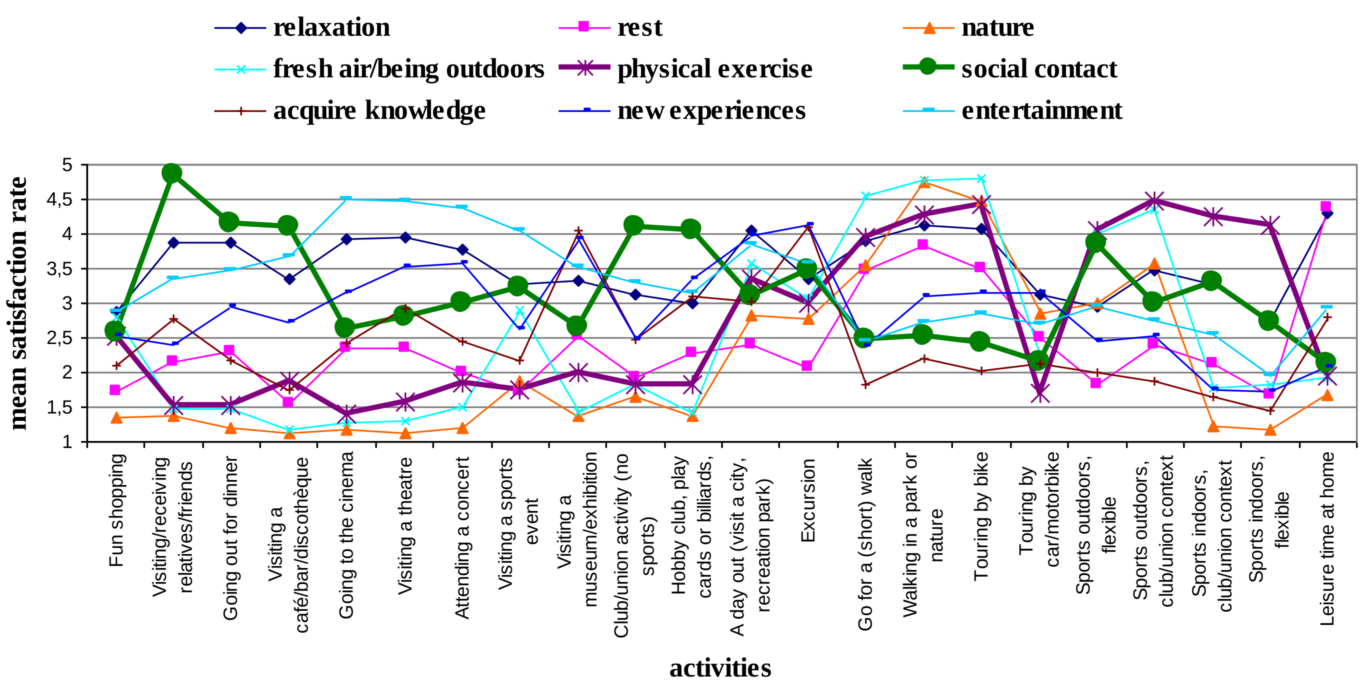
- Events generate activities before, during and after the event

Survey in Eindhoven region: events appear to be responsible for a substantial proportion of travel demand

Basic needs

	Housekeeping	Daily goods	Physical exercise	Green recreation	Social	Entertainment	Rest	…..
Housekeeping	↓		↓			↑	↑	
Daily shopping		↓	↓		↓	↓	↑	
Fitness			↓	↓		↓	↑	
Visit a park				↓			↓	
Visit a friend					↓	↓	↑	
Work			↑		↓	↑	↑	
….								
Travel by car						↓		
….								

Survey results (Nijland et al. 2010)

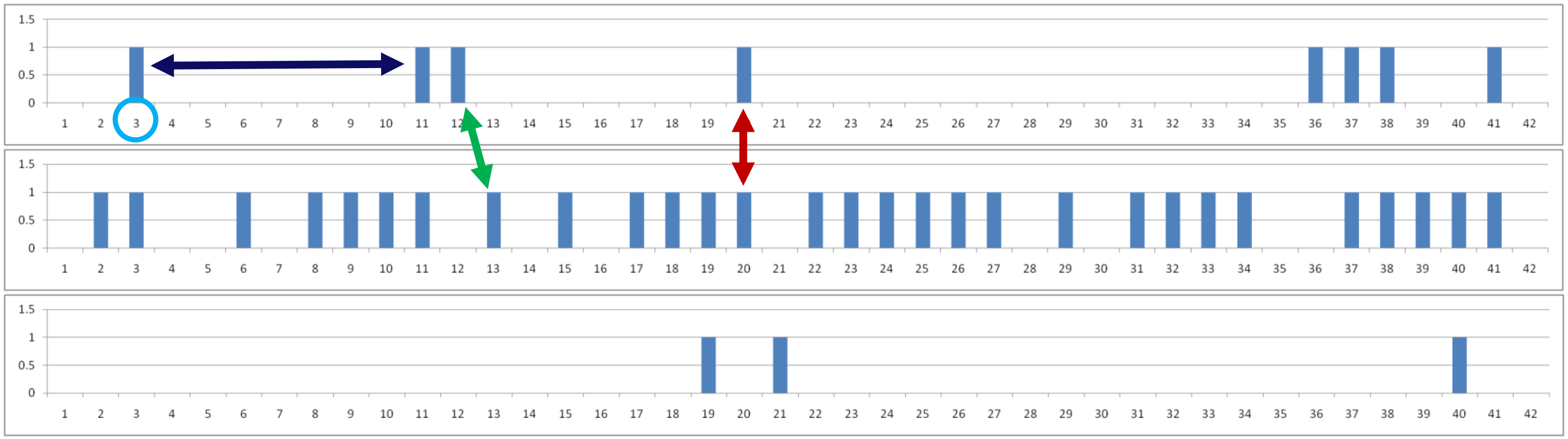


- There is a limited number of needs
- There is a many-to-many correspondence between activities and needs

➢ Substitution relationships between activities

Time dependencies between choices

Example: observed activities in 42 days time frame



Need rebuild time

Cross generation effects

Combining activities

Day varying conditions

We need multi-days time frames for analysis and prediction of activity choices

Built environment

Travel choices

Supernetworks

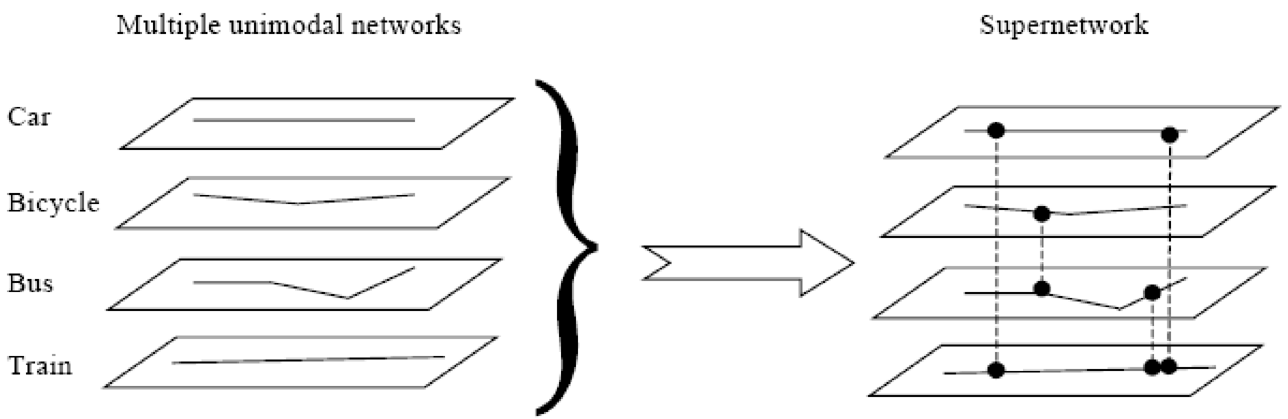
Travel choices – supernetwork approach

- Philosophy
  - Integrated view on land-use and transportation system
  - Look at ways to
    - Reduce travel demands induced by activity agendas

- Hypothesis
  - Activity induced travel demand can be reduced by better synchronization of
    - Transport networks of different modalities
    - Transport networks and activity locations
    - Transport networks and ICT

Supernetworks = multi-modal networks

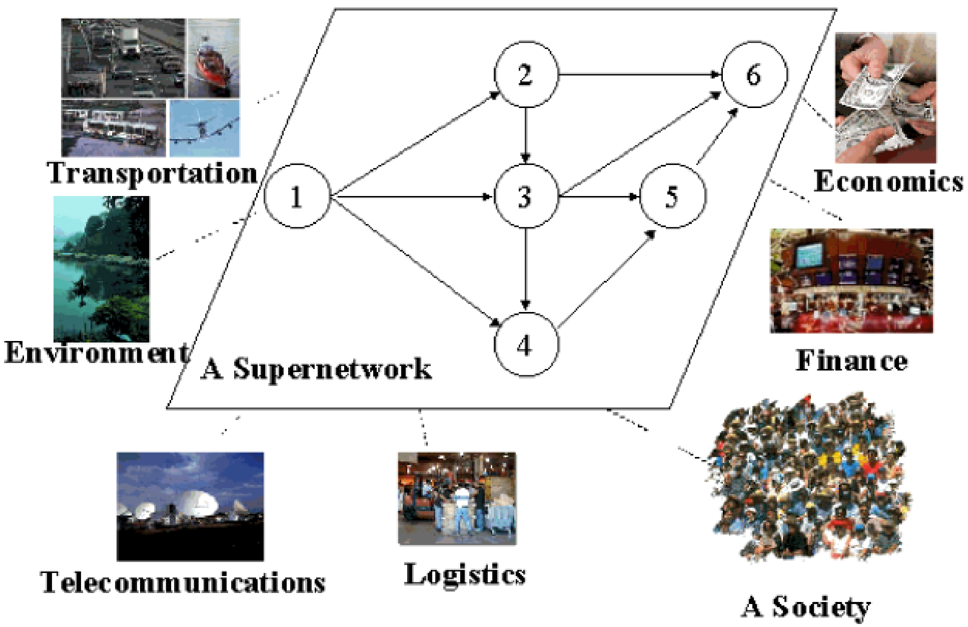
Basic concept by Sheffy (1985) and Carlier et al. (2002)



Shortest-path algorithms can be used for multi-modal routing

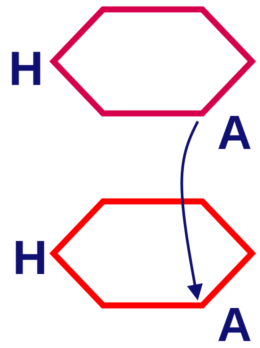
Supernetworks = transport + transactions

Extensions by Nagurney et al. (2003)

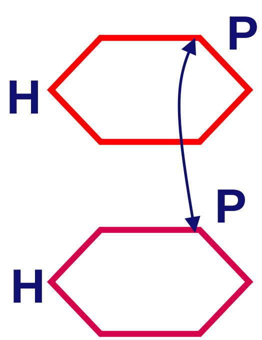


Supernetworks = transport + activities

Extensions by Arentze and Timmermans (2004)



Activity state transition links

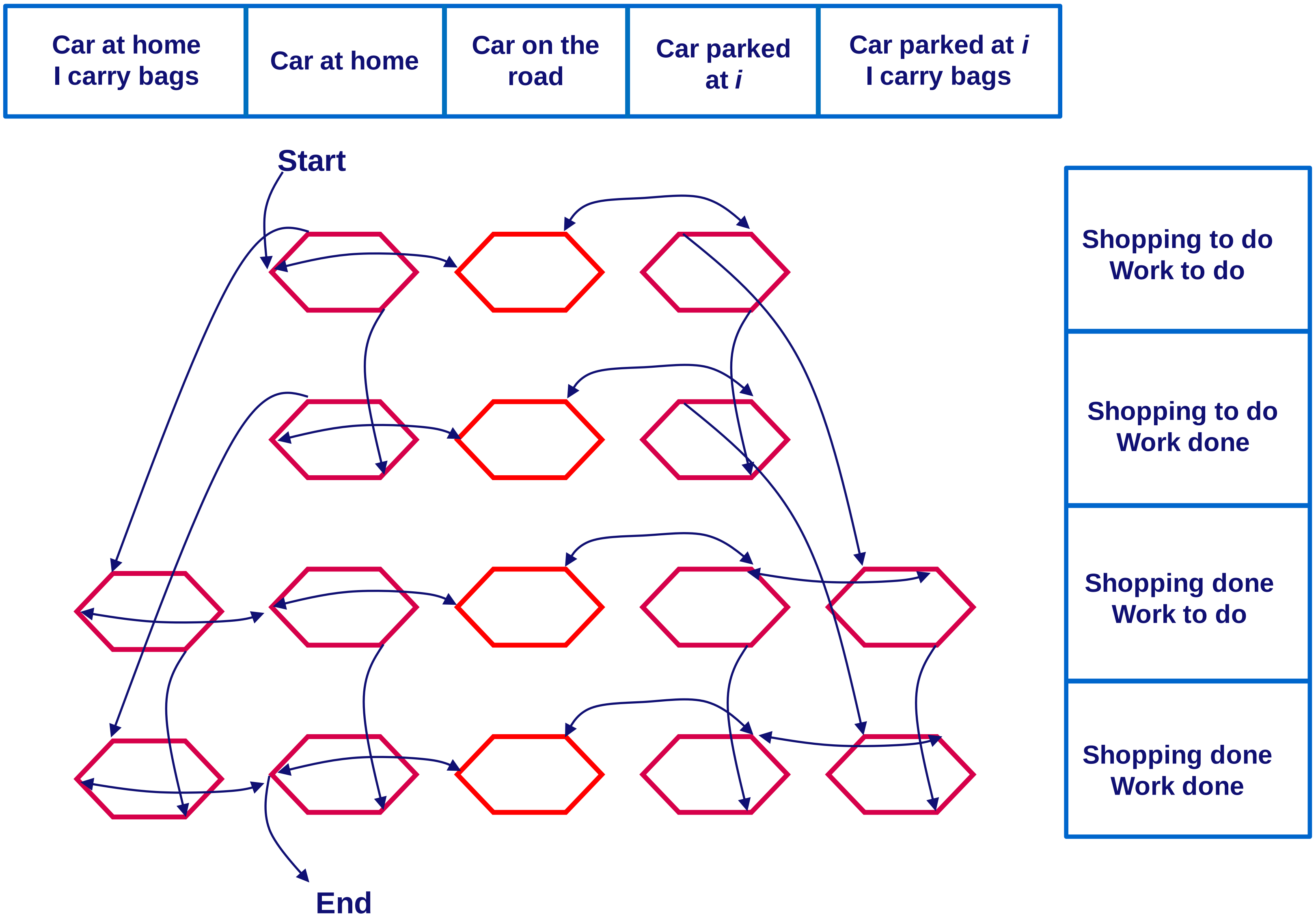


Parking state transition links

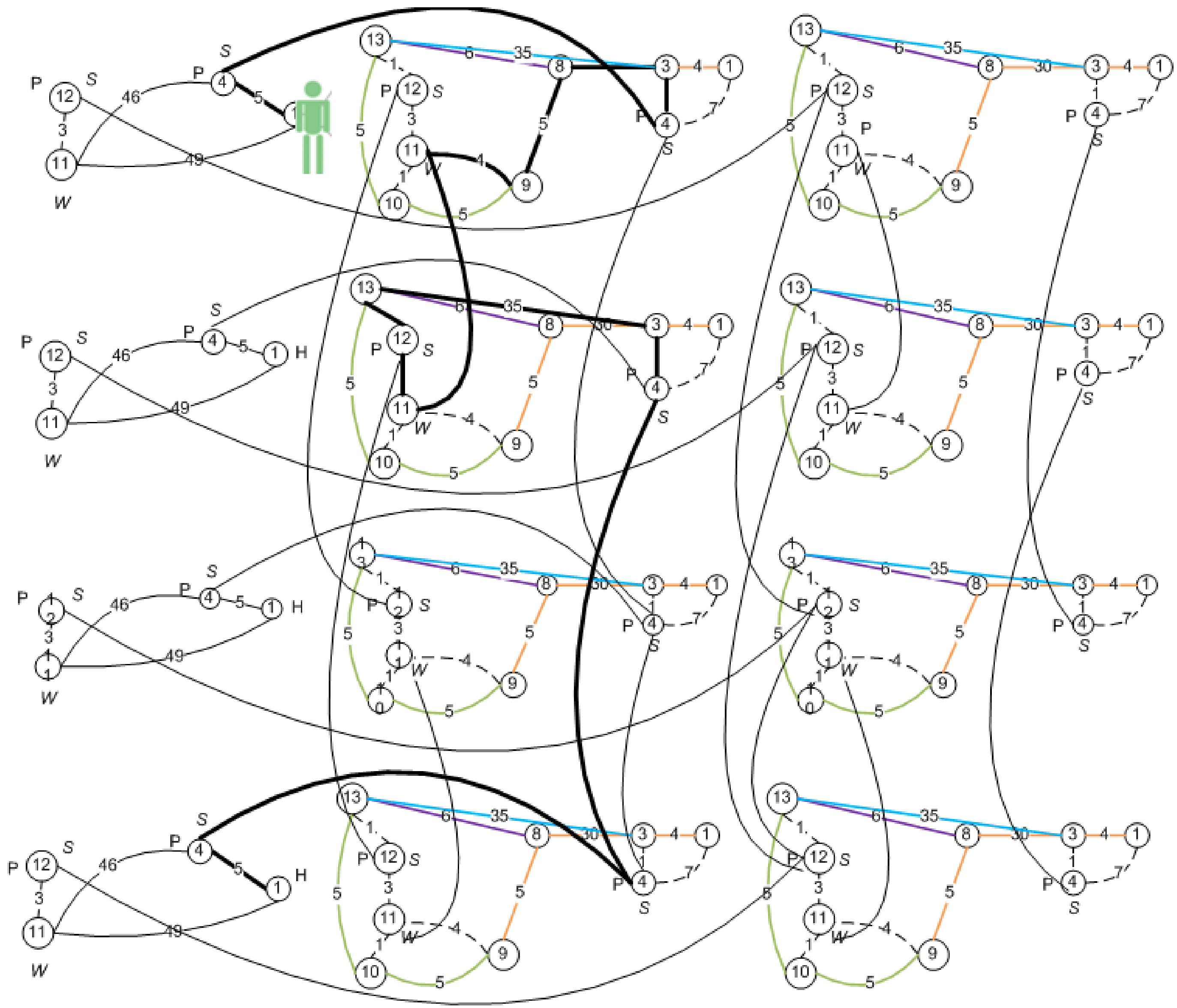
Link costs are state-dependent

$$c_j = (\varpi_{m,s}(\mathbf{x}_j) + \pi_s)t_j + \delta_m d_j + \chi_{m,s}(\mathbf{x}_j)$$

Supernetwork – transport + activities



Further development by Liao et al. (2009)



Example of a path

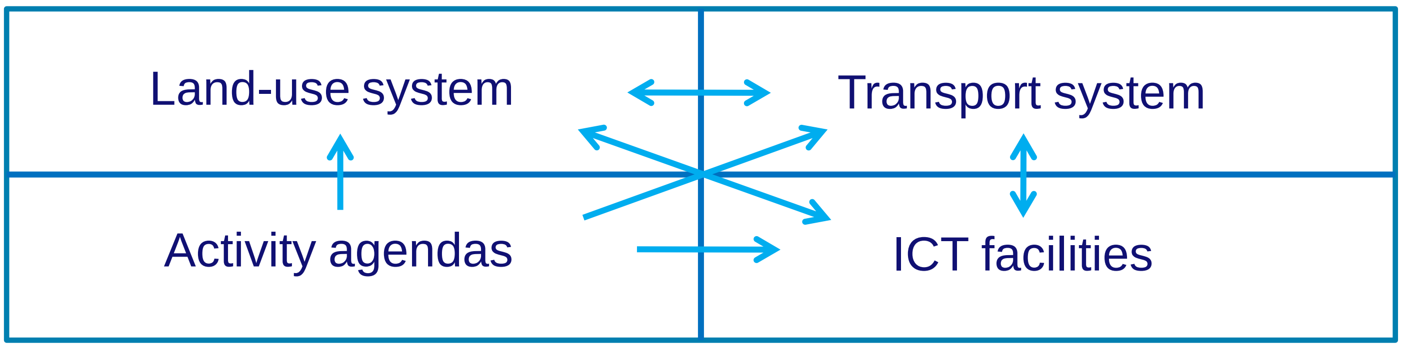
Mode	From	To	Line	Car_at	Bike_at	Worked	Shopped	Carry	Time
bike from home	1	1	0	home	0	no	no	no	0
bike	1	4	0	home	0	no	no	no	20
bike	4	3	0	home	0	no	no	no	2
park bike	3	3	0	home	3	no	no	no	0
board	3	3	1	home	3	no	no	no	8
transit	3	8	1	home	3	no	no	no	18
transit	8	9	1	home	3	no	no	no	3
transfer	9	9	3	home	3	no	no	no	3
transit	9	10	3	home	3	no	no	no	5
alight	10	10	0	home	3	no	no	no	4
walk	10	11	0	home	3	no	no	no	8
work	11	11	0	home	3	yes	no	no	0
walk	11	10	0	home	3	yes	no	no	8
board	10	10	3	home	3	yes	no	no	4
transit	10	9	3	home	3	yes	no	no	5
transfer	9	9	1	home	3	yes	no	no	6
transit	9	8	1	home	3	yes	no	no	3
transit	8	3	1	home	3	yes	no	no	18
alight	3	3	0	home	3	yes	no	no	8
get bike	3	3	0	home	0	yes	no	no	0
bike	3	4	0	home	0	yes	no	no	2
park bike	4	4	0	home	4	yes	no	no	0
shop	4	4	0	home	4	yes	yes	yes	0
get bike	4	4	0	home	0	yes	yes	yes	0
bike	4	1	0	home	0	yes	yes	yes	20
bike to home	1	1	0	home	home	yes	yes	no	0

Conclusion

- **Simultaneous modeling of all choices for implementation of an activity program**
  - **Sequence of activities**
  - **Location of activities**
  - **Transport mode(s) and transfers**
  - **Route choice**
  - **Use of ICT (including multitasking)**

Hypothesis – revisited

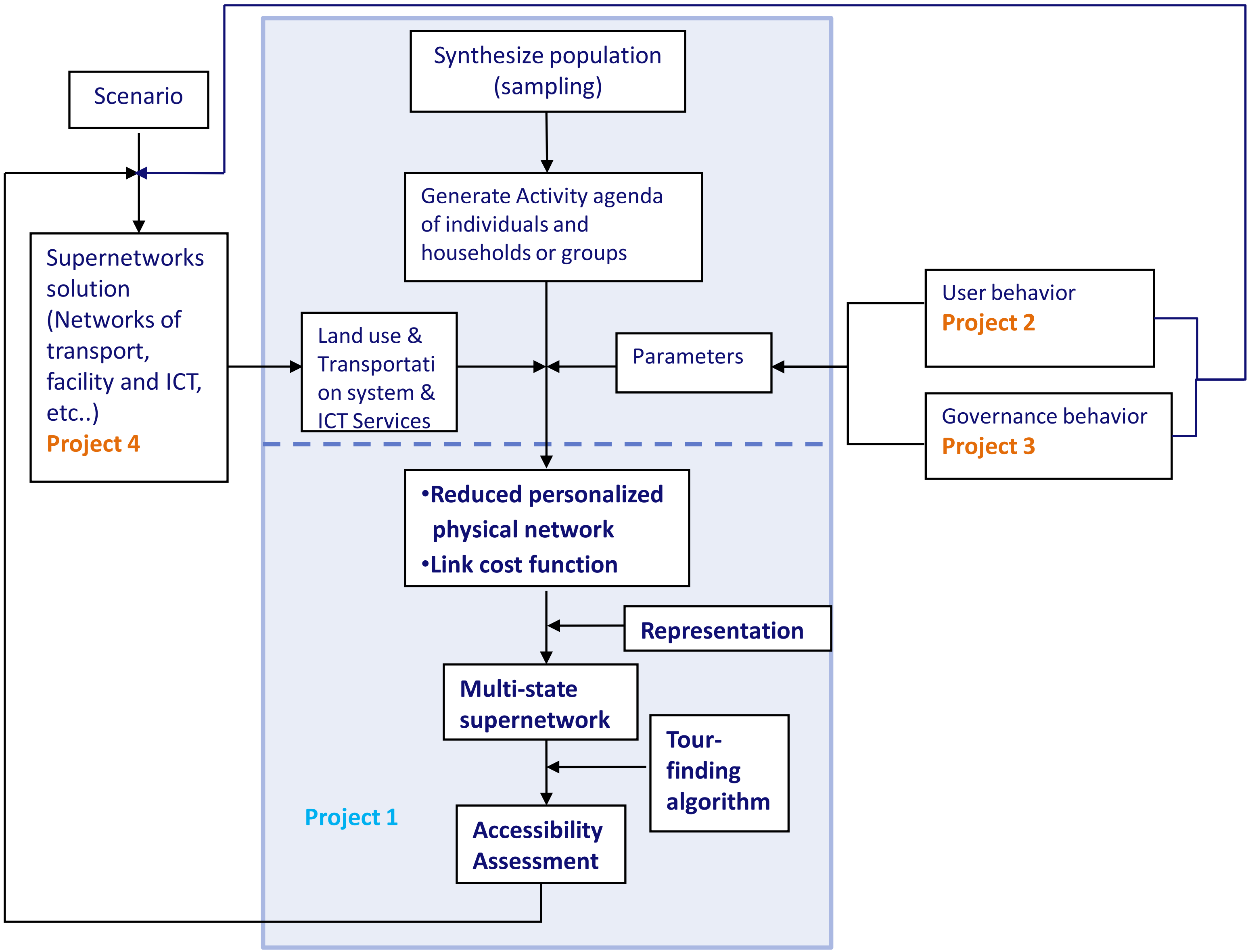
By synchronizing subsystems



Travel demands can be reduced

This hypothesis is currently under investigation in a broader research program (Molin et al. 2009)

A tool for policy evaluation (Molin et al. 2009)



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