

CIE4801 Transportation and spatial modelling

Spatial modelling: Land use and transportation models

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17/4/13

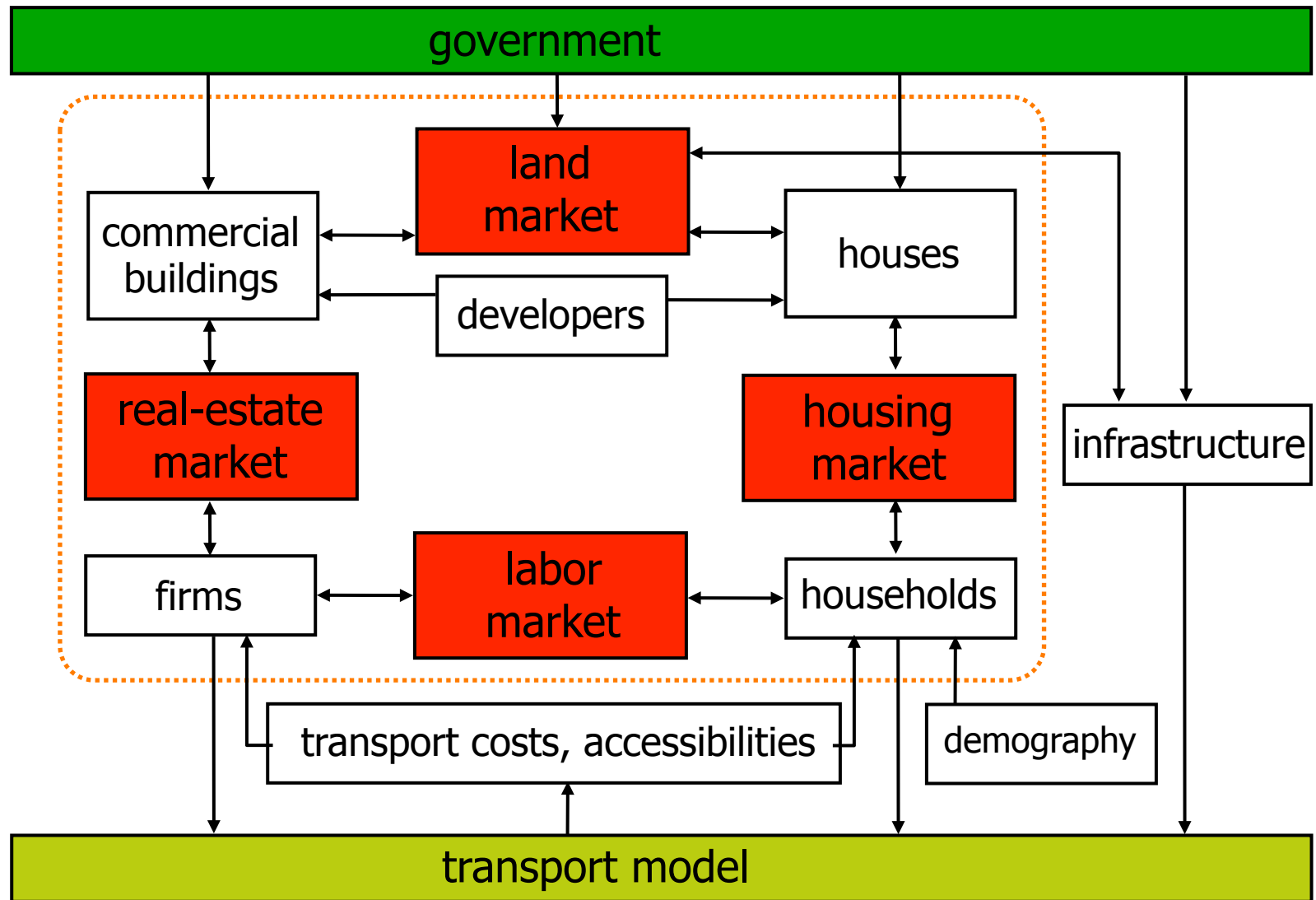
Content

- Land use and transportation models (LUT)
 - UrbanSim
 - TIGRIS XL
 - TIGRIS XL Applications
- Choice modelling
 - Firm location behaviour
 - Household location behaviour
- Circle of Wegener revisited

1.

Land use and transportation models

LUT models: Framework

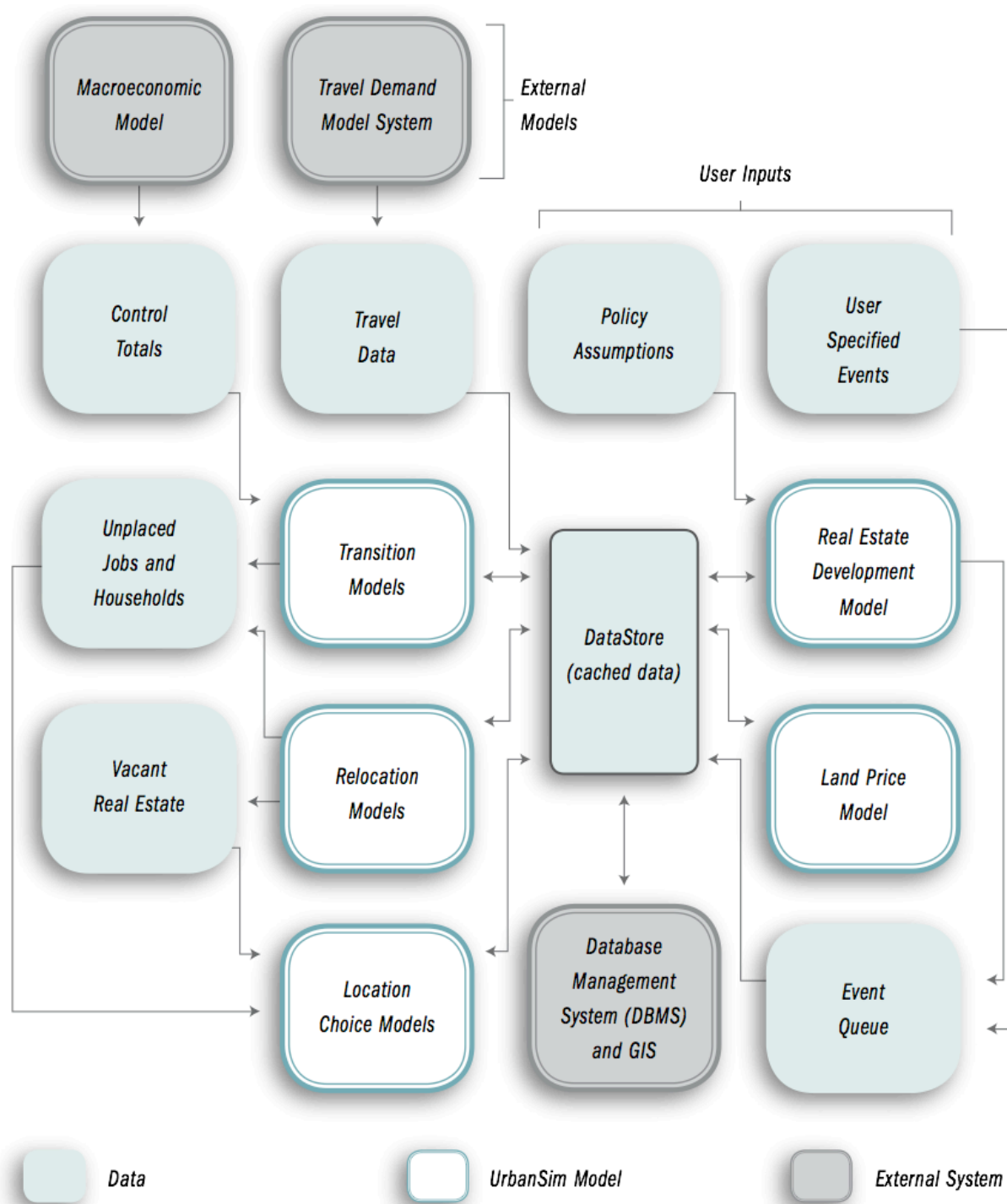


1.1

UrbanSim

UrbanSim: Modelling approach

- Models choices of decision-makers in a theoretic framework
- Models processes using multinomial or nested logit
- Microsimulation of individual decision-makers
- Dynamically simulate annual time steps
- Models market interactions
- Uses very disaggregate spatial units



UrbanSim: Inputs and outputs

(per grid cell, 150m x 150m)

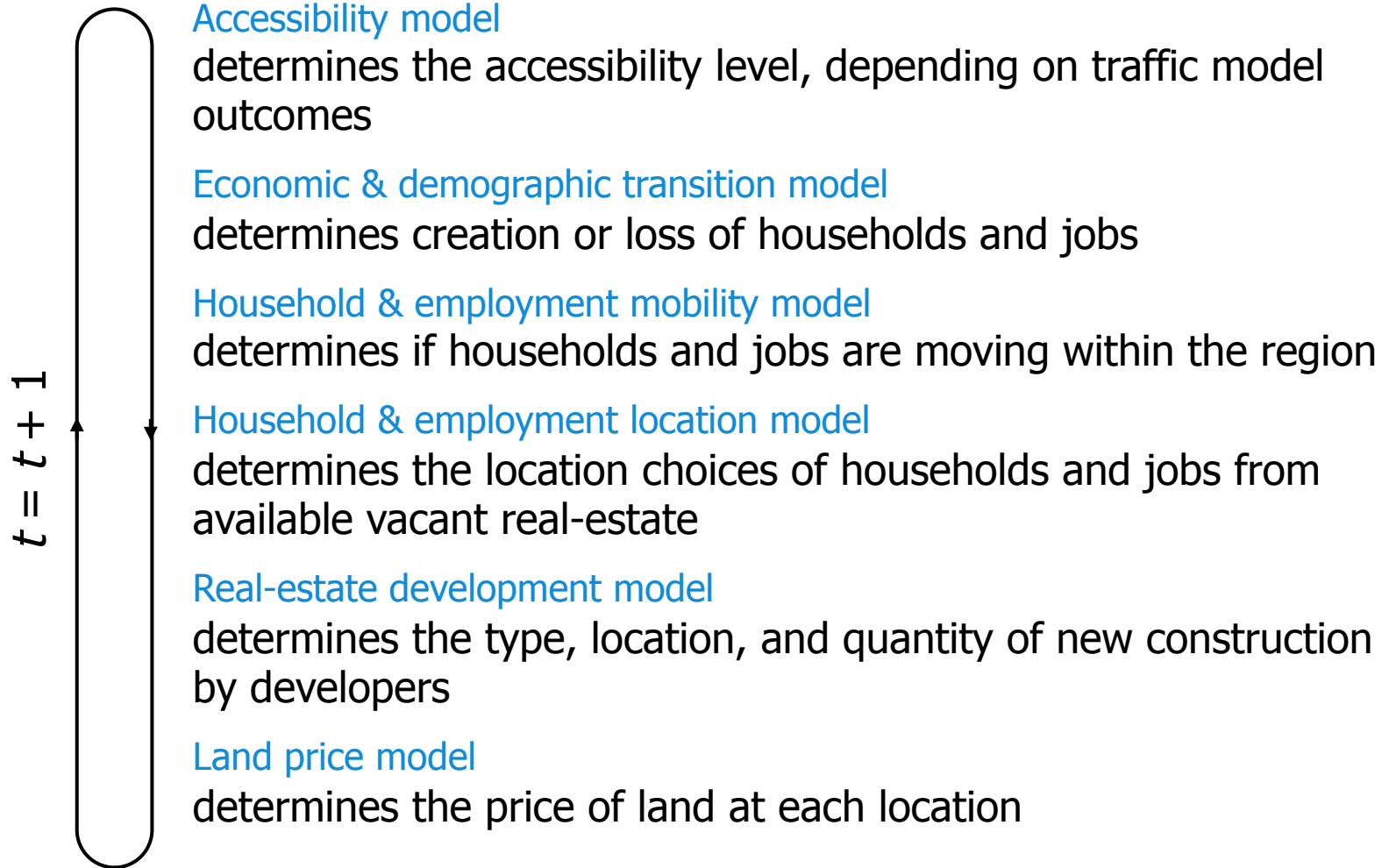
INPUT

- inhabitants (census data)
- land ownership parcels
- firms
- household travel survey
- land use plan
- environmental constraints
- transportation system

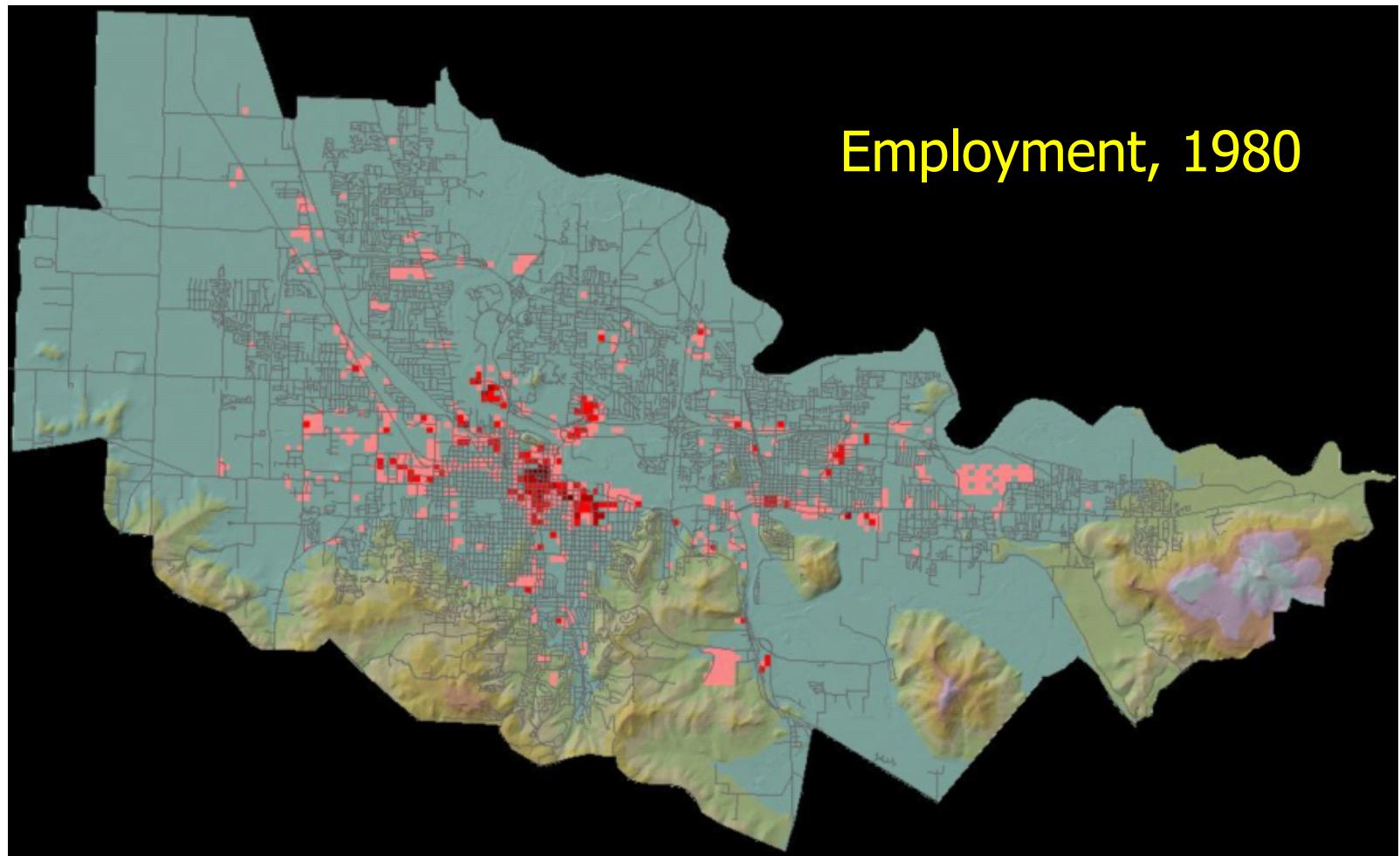
OUTPUT

- households
- employment by type
- real-estate development
- real-estate prices

UrbanSim: Model structure

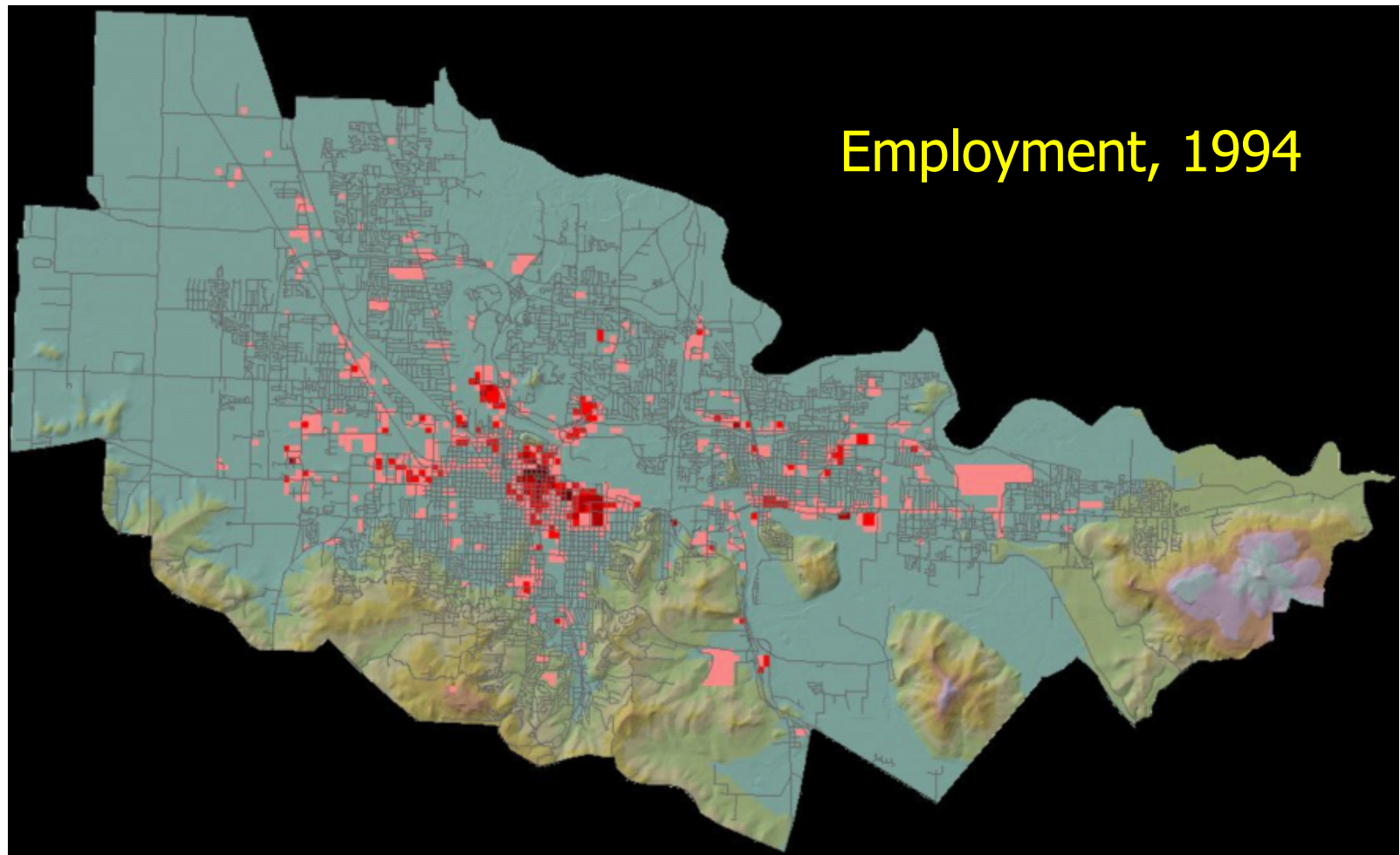


UrbanSim: some results (1/3)



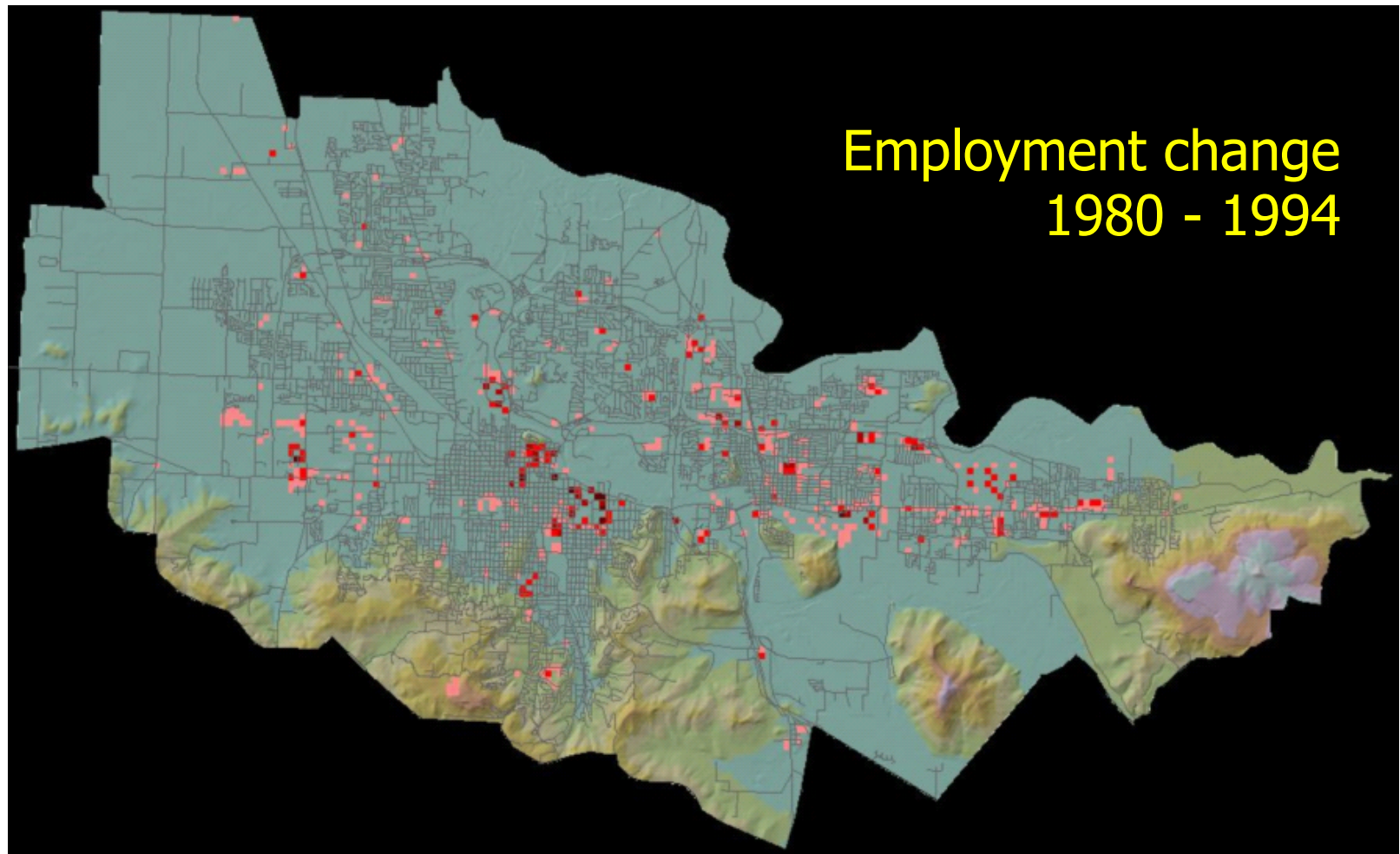
Eugene-Springfield (Oregon, USA)

UrbanSim: some results (2/3)



Eugene-Springfield (Oregon, USA)

UrbanSim: some results (3/3)



Eugene-Springfield (Oregon, USA)

1.2

TIGRIS

TIGRIS

- Transport Infrastructure Land-use ('Grondgebruik')
Interaction Simulation
- Developed in the 90's
- Primarily based on expert judgement
 - Model structure as well as parameters
- Meant to be a sketch-planning model
 - GIS-based, incremental development (year by year), dashboard

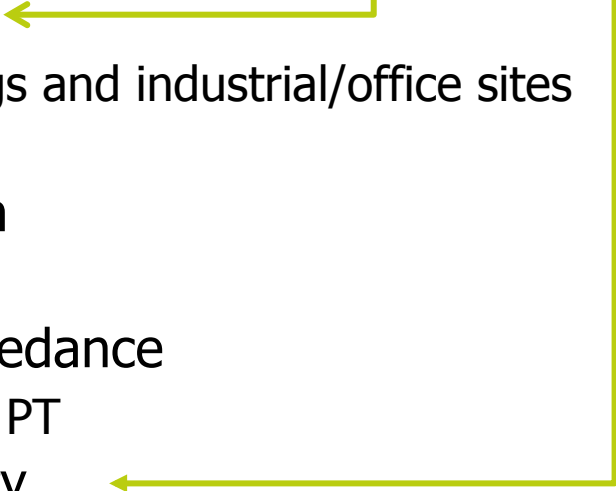
TIGRIS: Flow chart



Figure 2. Attractions submodel

Land use is characterised by population, jobs and amenities national and regional development determined on the basis of attraction. Dwelling construction per zone minimum and maximum number

TIGRIS: Submodels

- Attractiveness of a zone
 - Living and working
 - Land use 
 - Dwellings and industrial/office sites
 - Mobility
 - Congestion
 - Car
 - Travel impedance
 - Car and PT
 - Accessibility 
 - Amenities, population, jobs
- To be used in year $t+1$
- } 'equilibrium'
- 

TIGRIS: Applications

- Four applications
 - Randstadrail
 - Leiden-Haarlem-Amsterdam
 - Arnhem-Nijmegen
 - Randstad: Urbanisation beyond 2030
- Primarily used as an explorative model
 - Unclear role in planning processes
- Evaluation
 - Not state of the art (no choice modelling)
 - Not tailored to the questions in practice (e.g. link with economic analyses)

TIGRIS XL: Modelling approach

- Dynamic spatial allocation model
- Accessibility influences location choice
- Determines effects of infrastructure concepts on land use
- Determines effects of spatial planning on transportation
- Simulates annual changes
- Uses aggregate zones, no detailed spatial data
- Used for policy development, not for evaluation.

TIGRIS XL: inputs and output

INPUT

- zones
- inhabitants
- car ownership
- employment levels
- services
- captives and non-captives
- population growth factors
- spatial development policies
- coarse infrastructure network

OUTPUT

- households by type
- employment by type
- real-estate development
- real-estate prices
- trips
- travel times
- safety & environment

zones

COROP regions



Modules TIGRIS XL

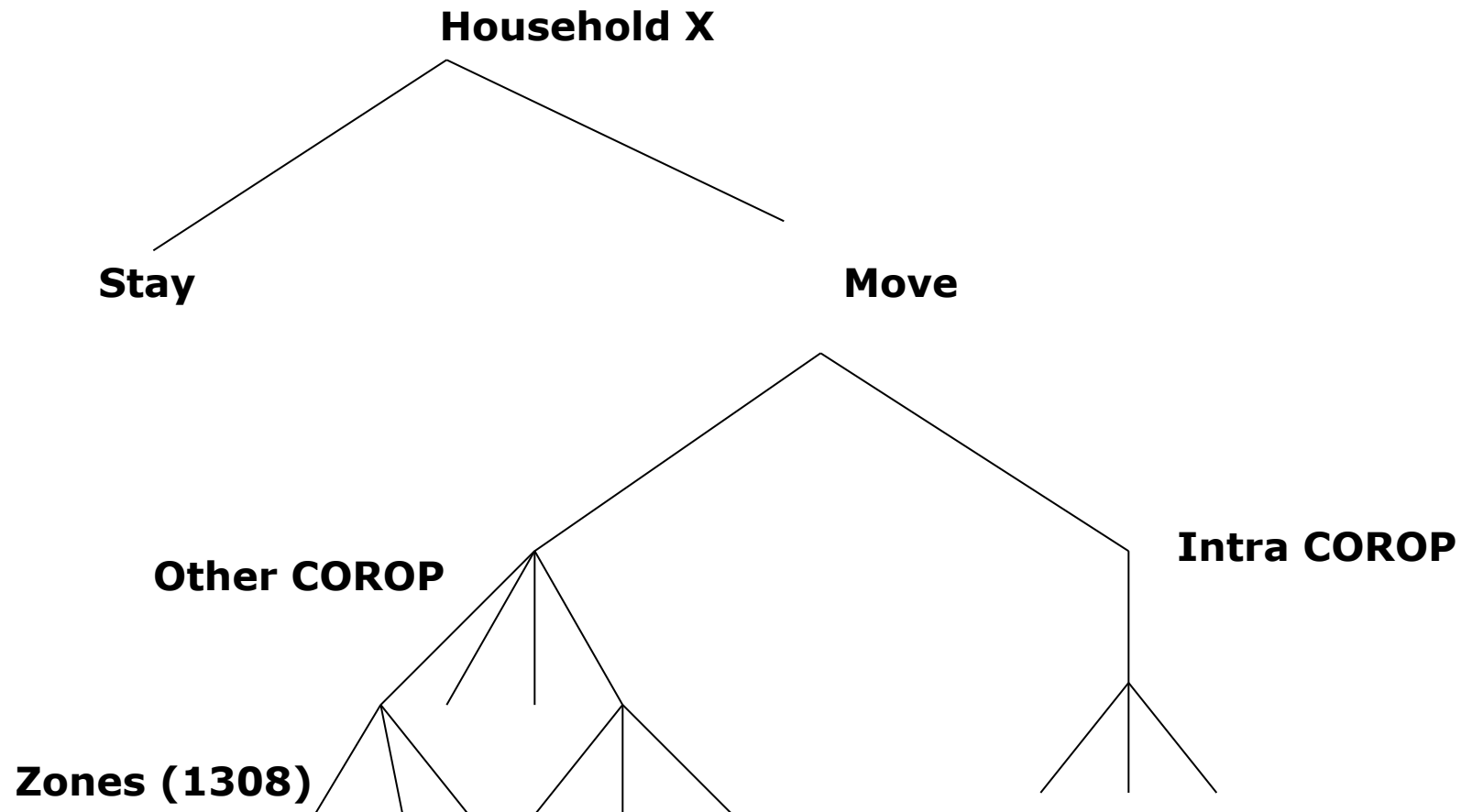
- **Demography** - module addressing basic demographic developments
- **Land market** - simplistic, excludes role of land-owner and project developers
- **Housing market** - behavioral choice model estimated on housing market survey
- **Labor market** - calibration on period 1986-2000
- **Transport module** - integration of land-use modules with LMS

Land market, role of government

TIGRIS XL can model different levels of government influence on the spatial development:

- **Regulated development (‘directed allocation’)**
spatial developments can only take place on planned locations
- **Free market development (‘free allocation’)**
spatial developments following preferences of households and firms. The developments are restricted by availability of land

Household choices



Household move/stay choice

Explanatory variables

- Household size
- Employment
- Household income
- Age head of household
- Zone type classification (urban to rural)
- Vacant houses in region
- Accessibility current location

Household location choice

Explanatory variables

- Number of vacant houses in a zone
- Average price of houses in a zone
- Zone type classification (urban – rural, 5 categories)
- travel time (travel time between old and new location)
- Accessibility location
- Zone characteristics (water, services, green, population density, etc.)

Firm choices

Identification of **economic sectors** is important, because these sectors show different location preferences and responses to transport measures.

Sectors in TIGRIS XL are:

- Agriculture
- Industry
- Logistics
- Retail sector
- Other consumer services
- Business services
- Government

Firm location choice

Explanatory variables

- Accessibility employees
- Population in a region
- Accessibility business
- Accessibility freight
- Agglomeration
- Urbanization
- Relative share of sector in a region

Accessibility variables

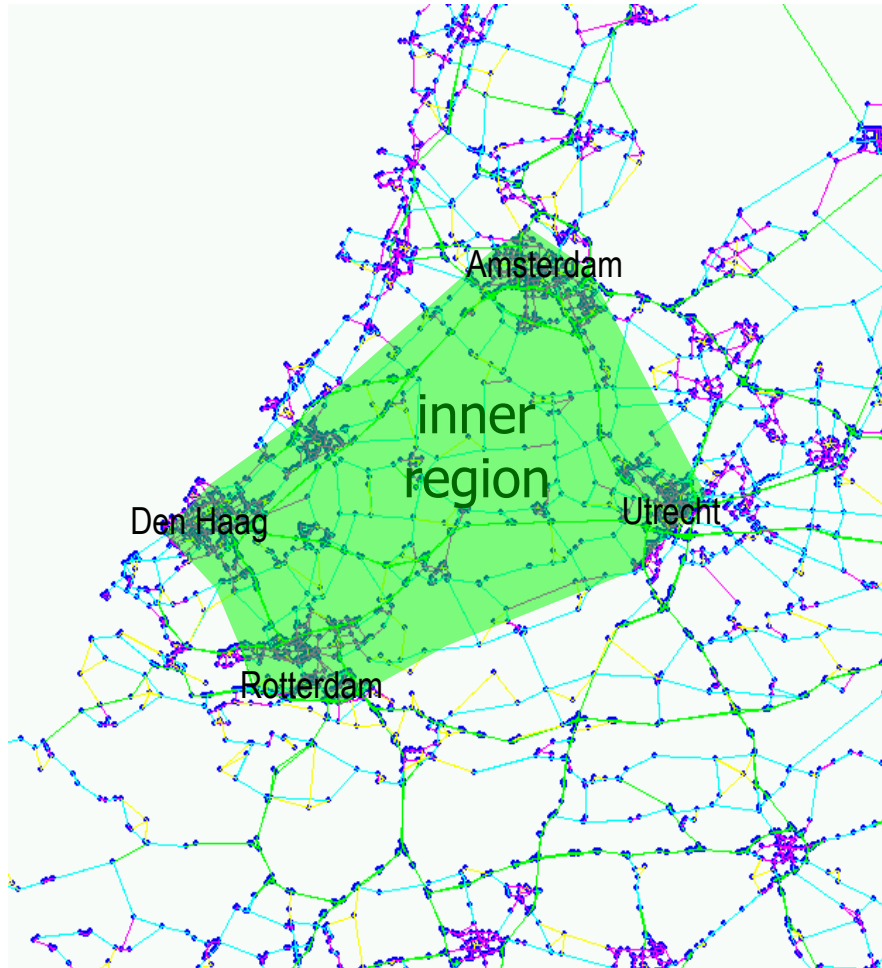
Utility based accessibility measures for (so-called logsum measures)

- Accessibility by household type
- Accessibility of firms for commuters
- Accessibility of firms for business

1.3

TIGRIS XL: Applications

TIGRIS XL: Randstad

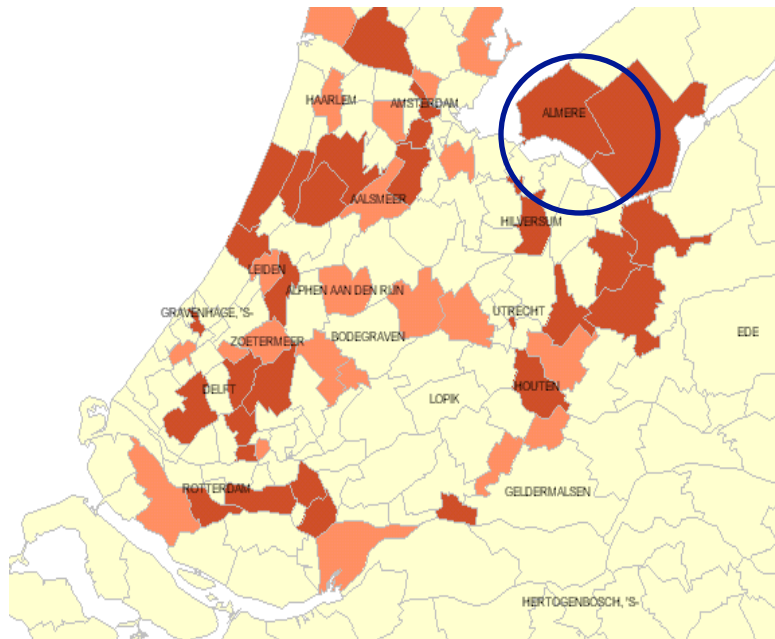


What are the consequences on land use and traffic when there is development

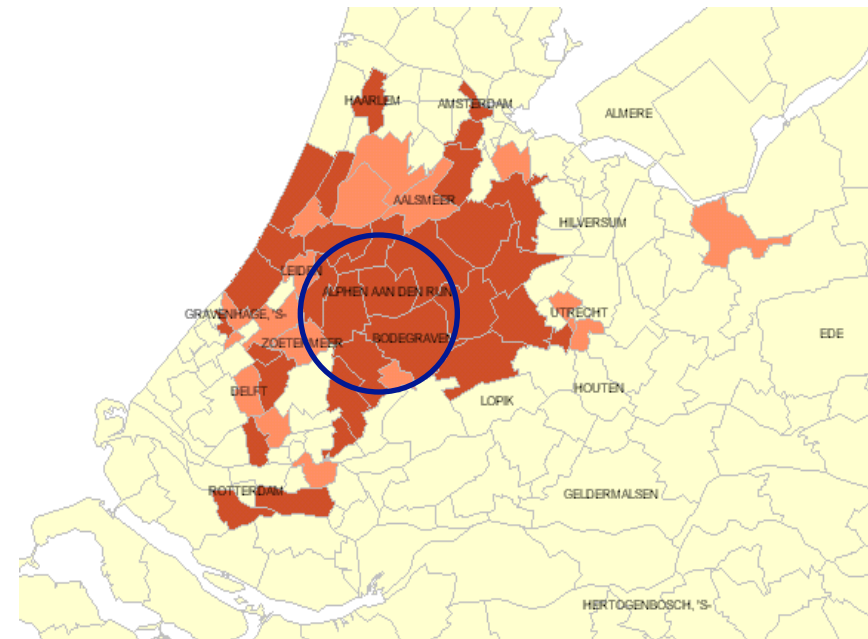
- in the outer region; or
- in the inner region

Randstad: results land use

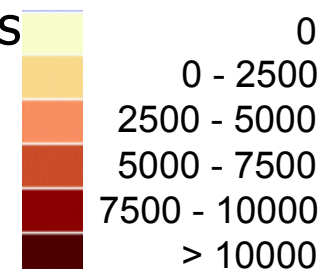
Developing in outer region



Developing in inner region

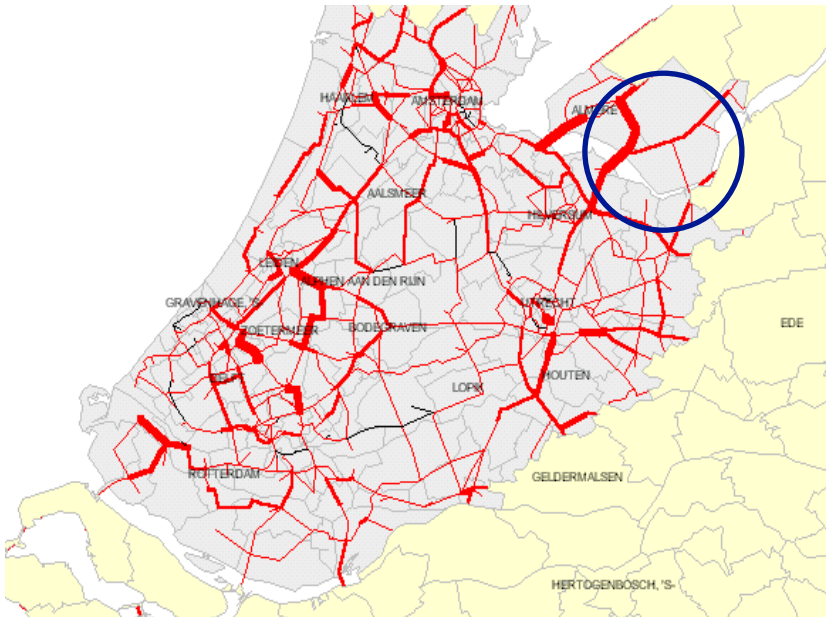


increase in houses
2010 - 2030

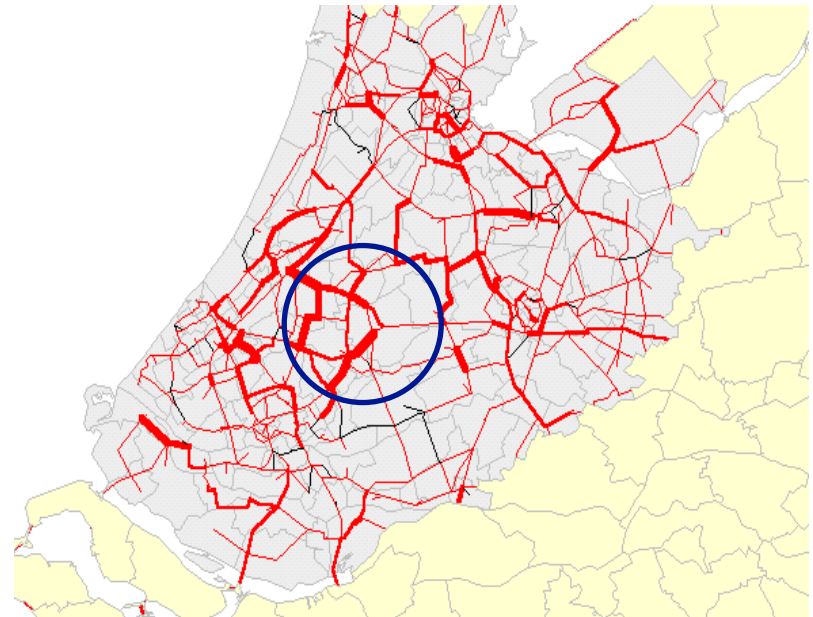


Randstad results transportation

Developing in outer region



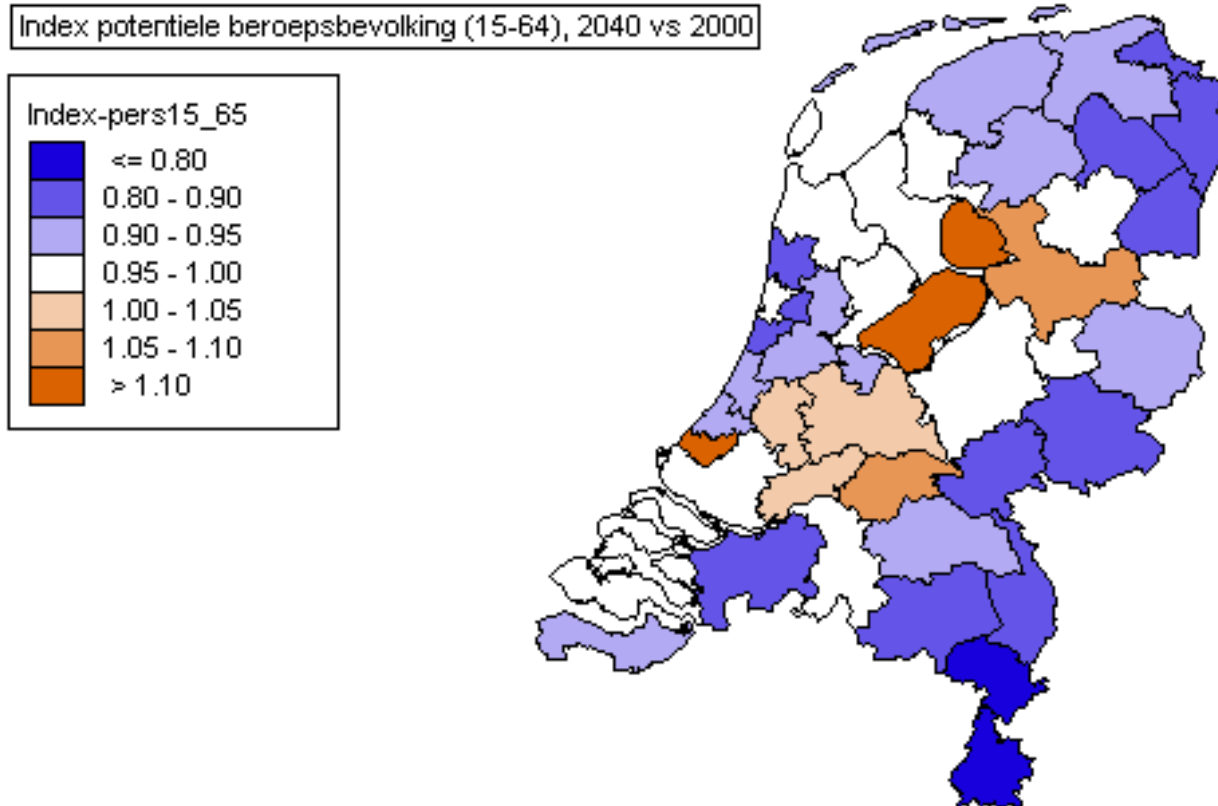
Developing in inner region



congestion
2010 - 2030

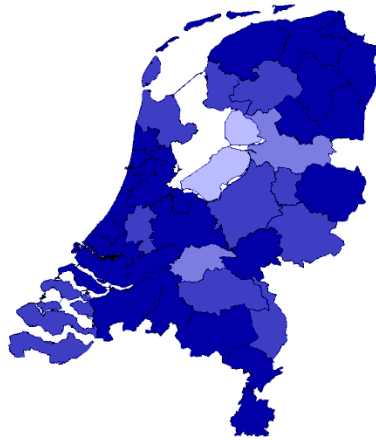
TIGRIS XL Trend scenario

Working population (15-64)

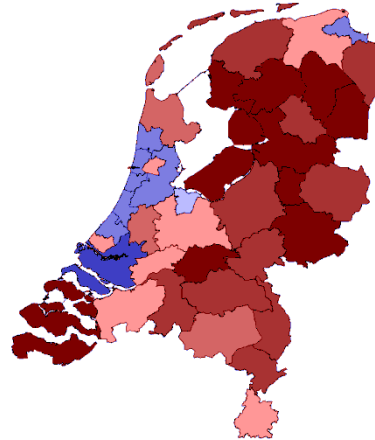


Results trend scenario

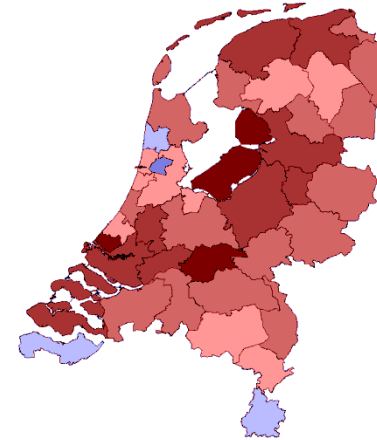
Jobs



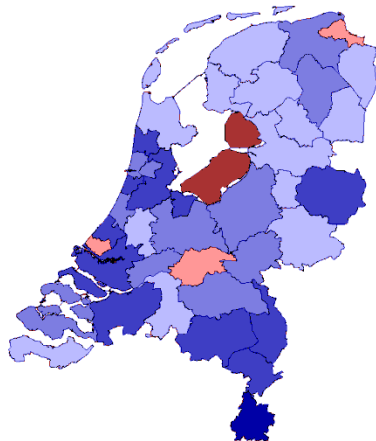
Industry



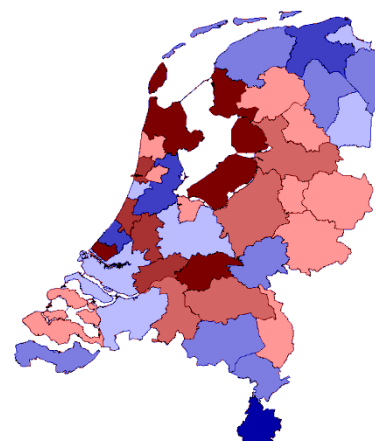
Logistics



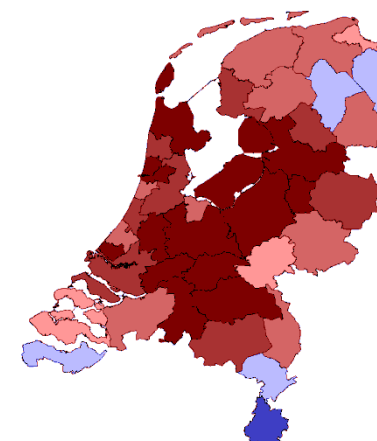
Retail



Other consumer services

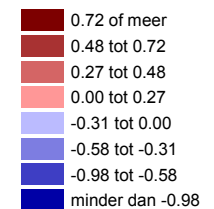


Business services

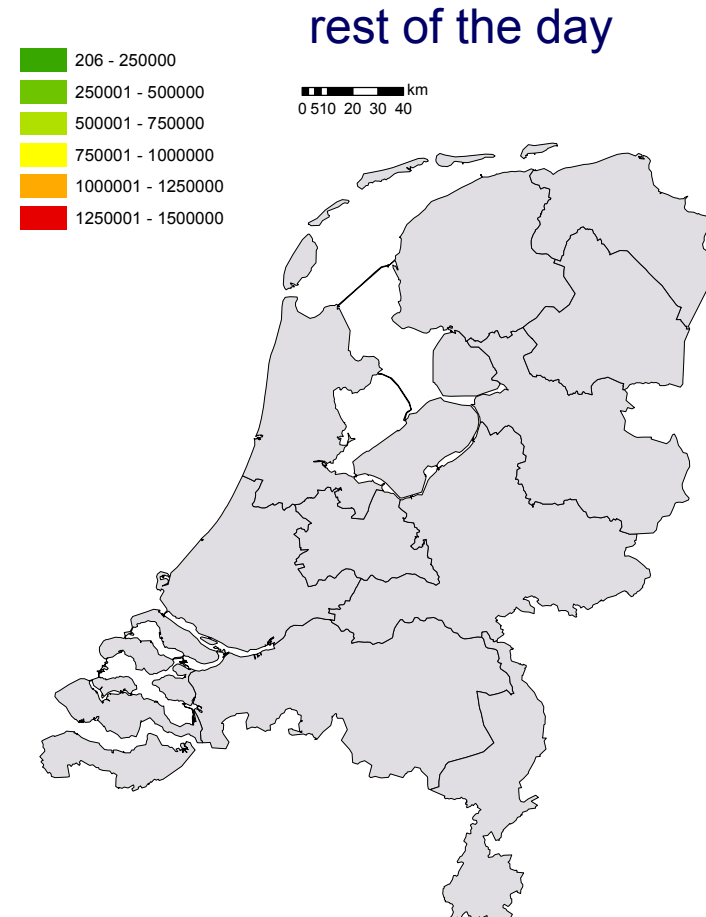


Government services

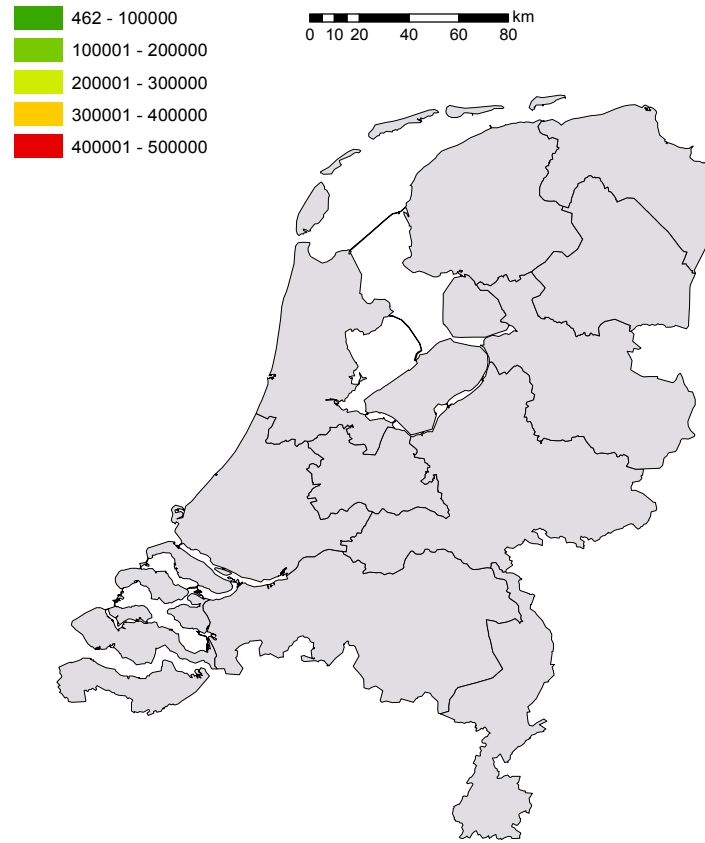
% per jaar



Accessibility of jobs for households (by car)

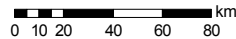
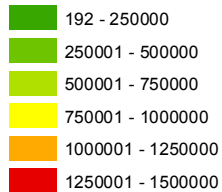


Accessibility of jobs for households (by public transport)

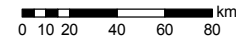
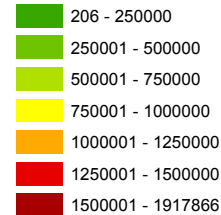


Accessibility of employees for firms (by car)

morning peak



rest of the day



Accessibility of employees for firms (by public transport)



Application concentration scenario

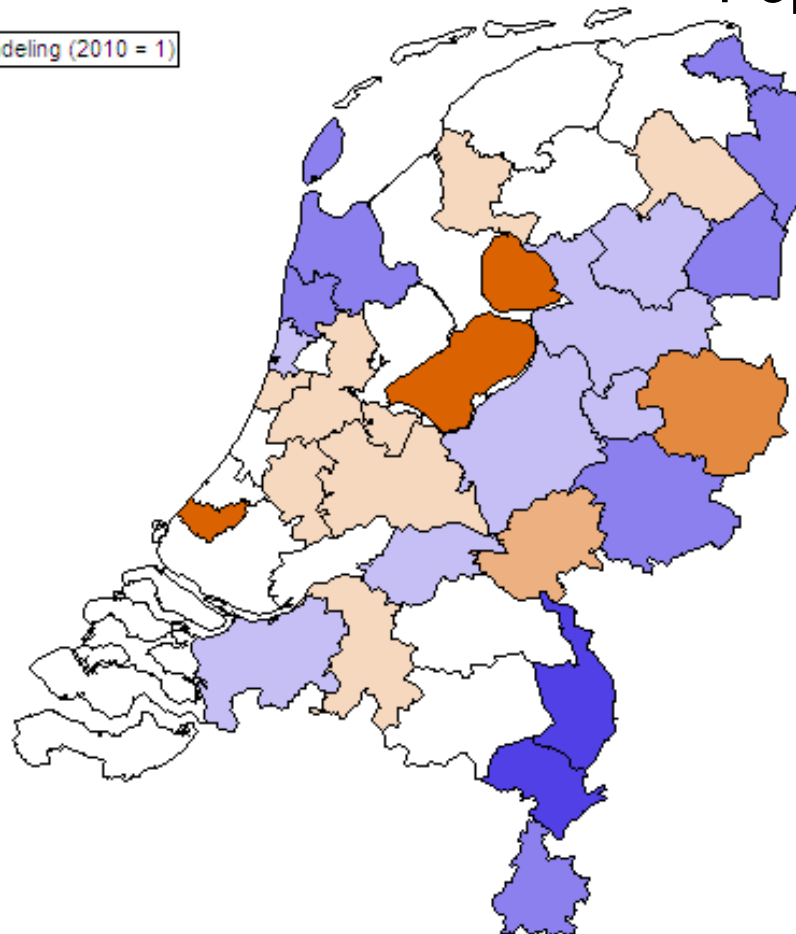
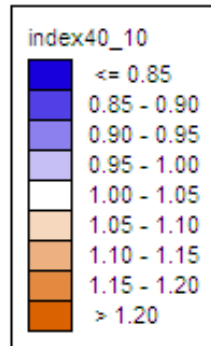
Appointed
concentration
areas



Results concentration scenario

Population

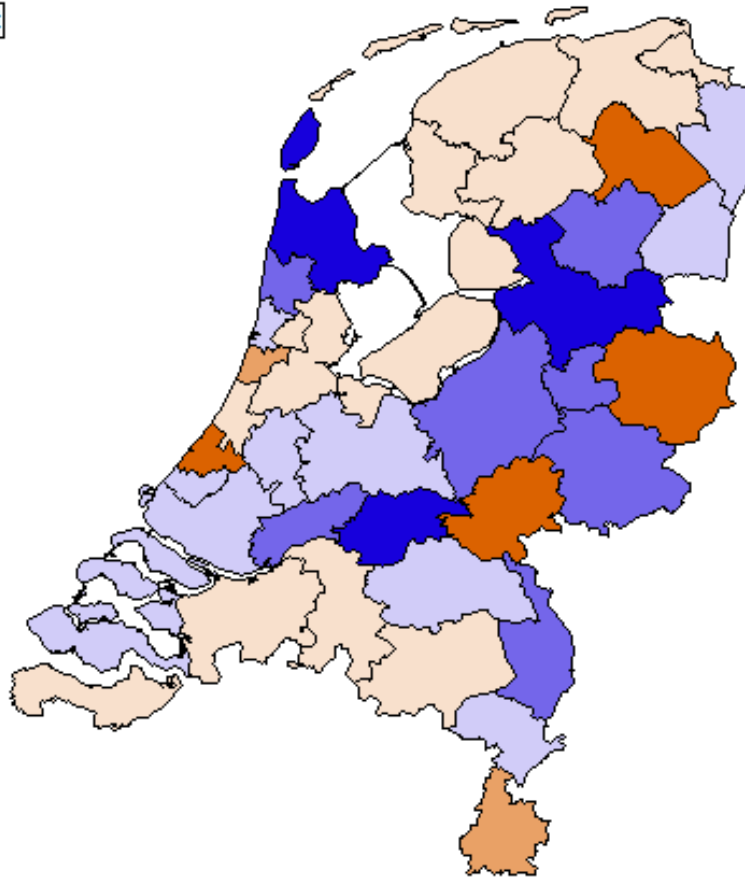
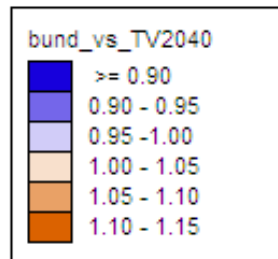
bevolkingsontwikkeling 2010-2040 bundeling (2010 = 1)



Results concentration scenario

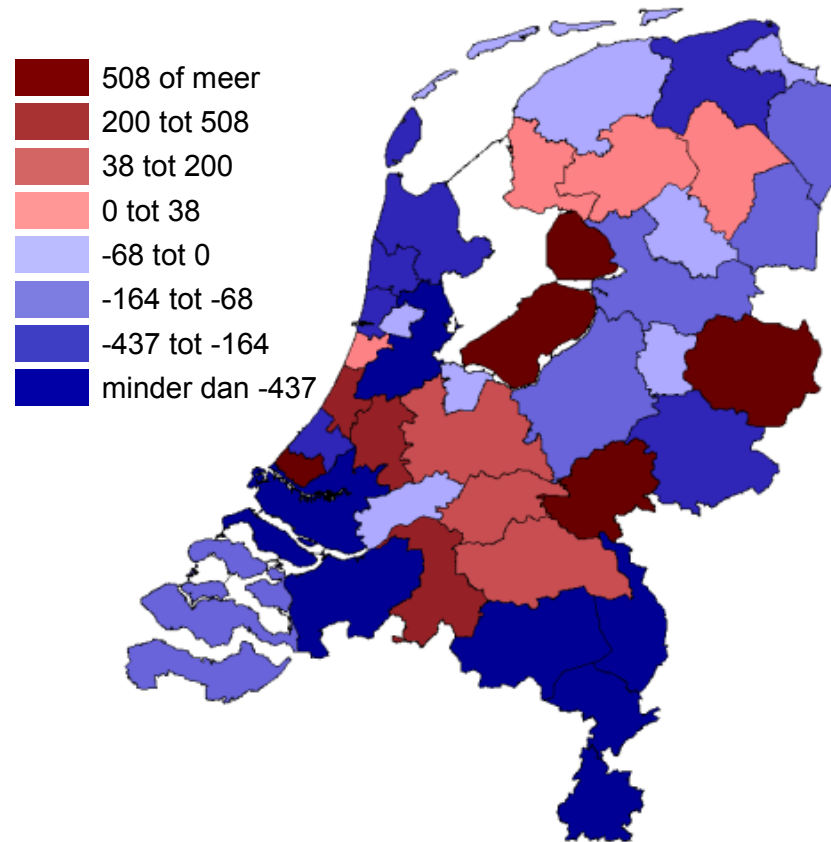
Population – concentration vs. trend

Bevolking 2040 bundeling vs trendvariant



Results concentration scenario

Arbeitsplaatsen per jaar Jobs – concentration vs. trend



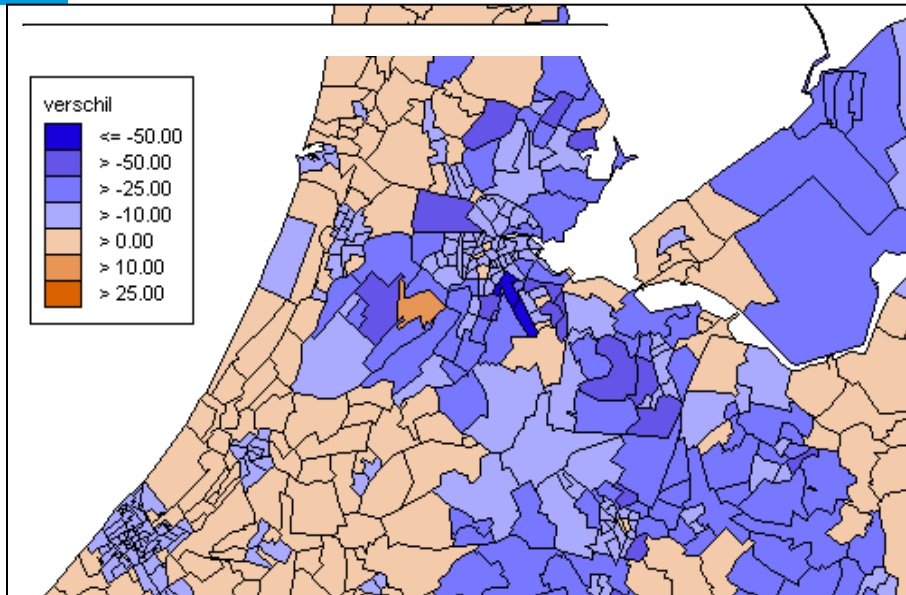
2.1

Choice modelling: firm location behaviour

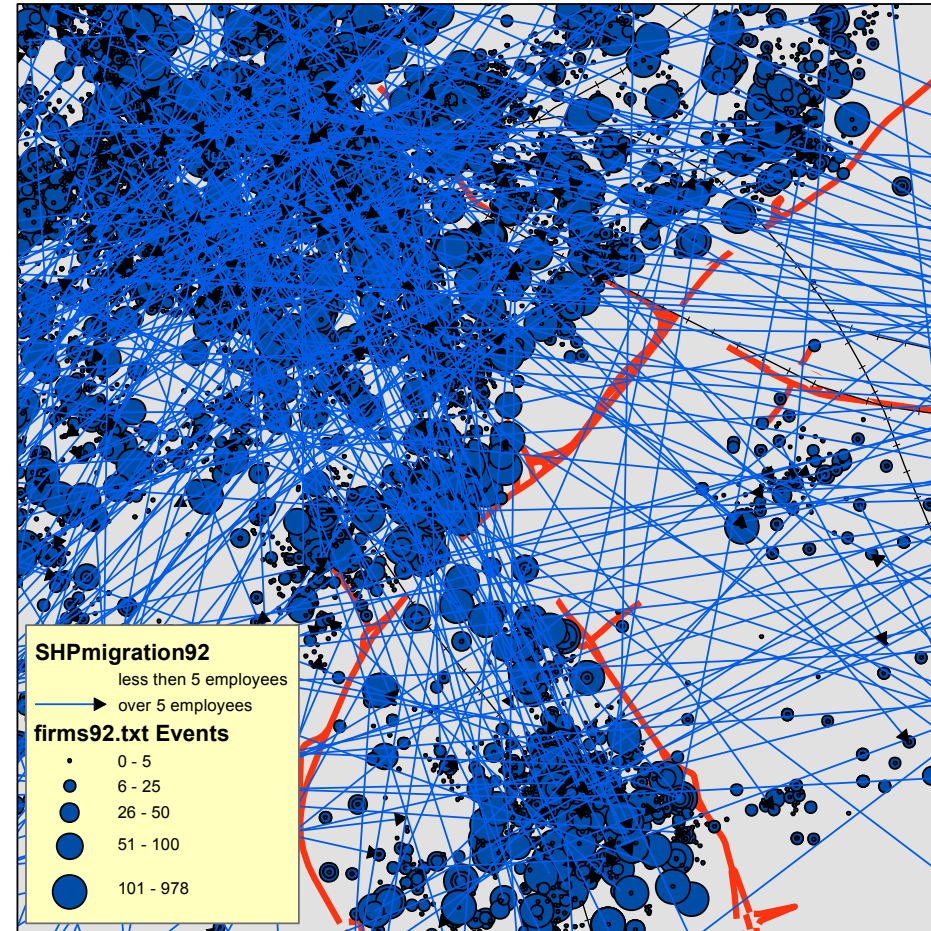
Factors influencing location choice of firms

- Characteristics of the firm
 - Size
 - Growth
 - Age
 - Sector
- Characteristics of the location
 - Vicinity of infrastructure
 - Accessibility of the market and of employees
 - Neighborhood of other firms

Aggregated approach:
All firms in a zone



Disaggregated approach:
Individual firms



Data available in the Netherlands

- LISA

National information system of employment, contains information on the whole firm population

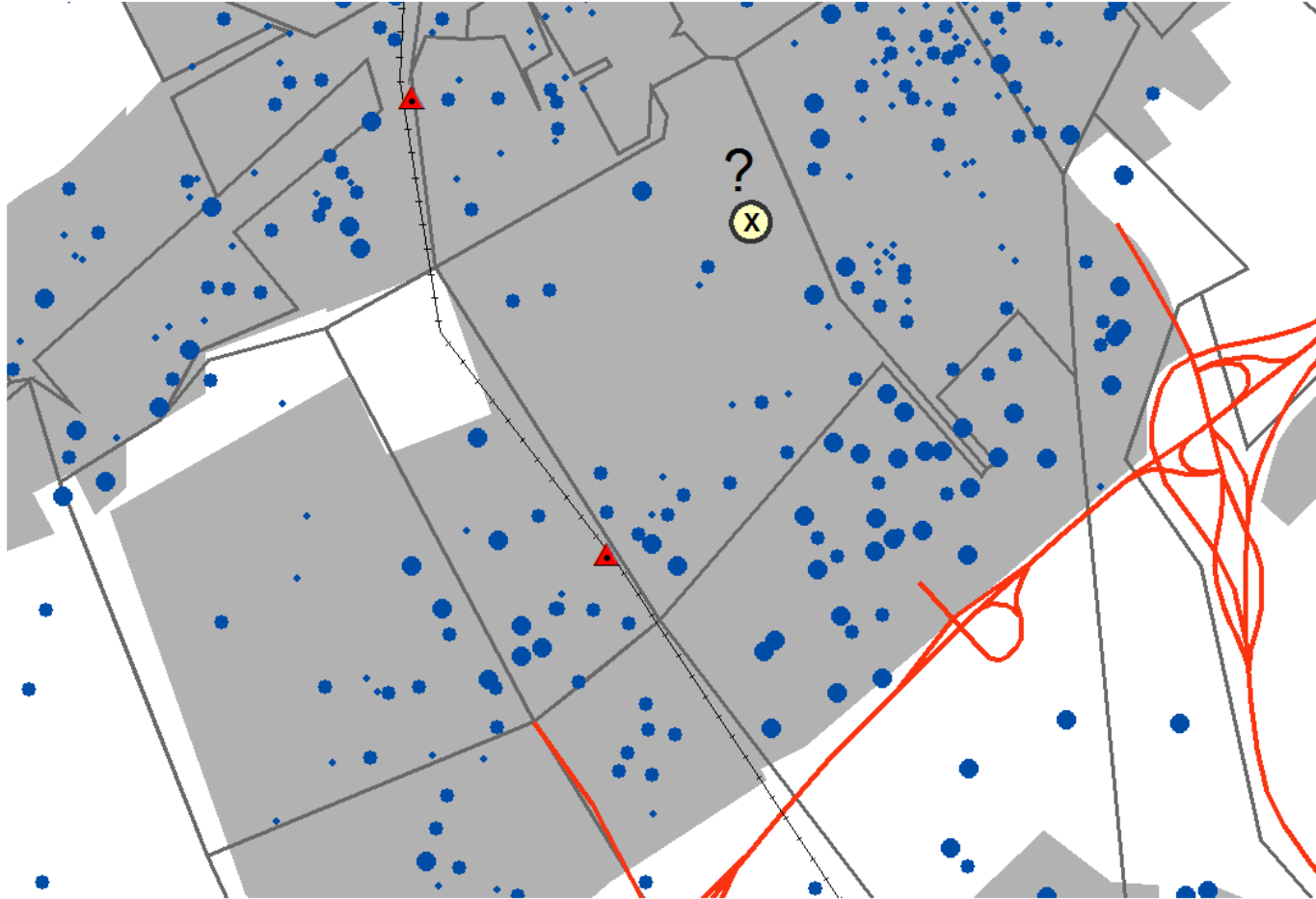
- LMS

National model system, contains information on accessibilities

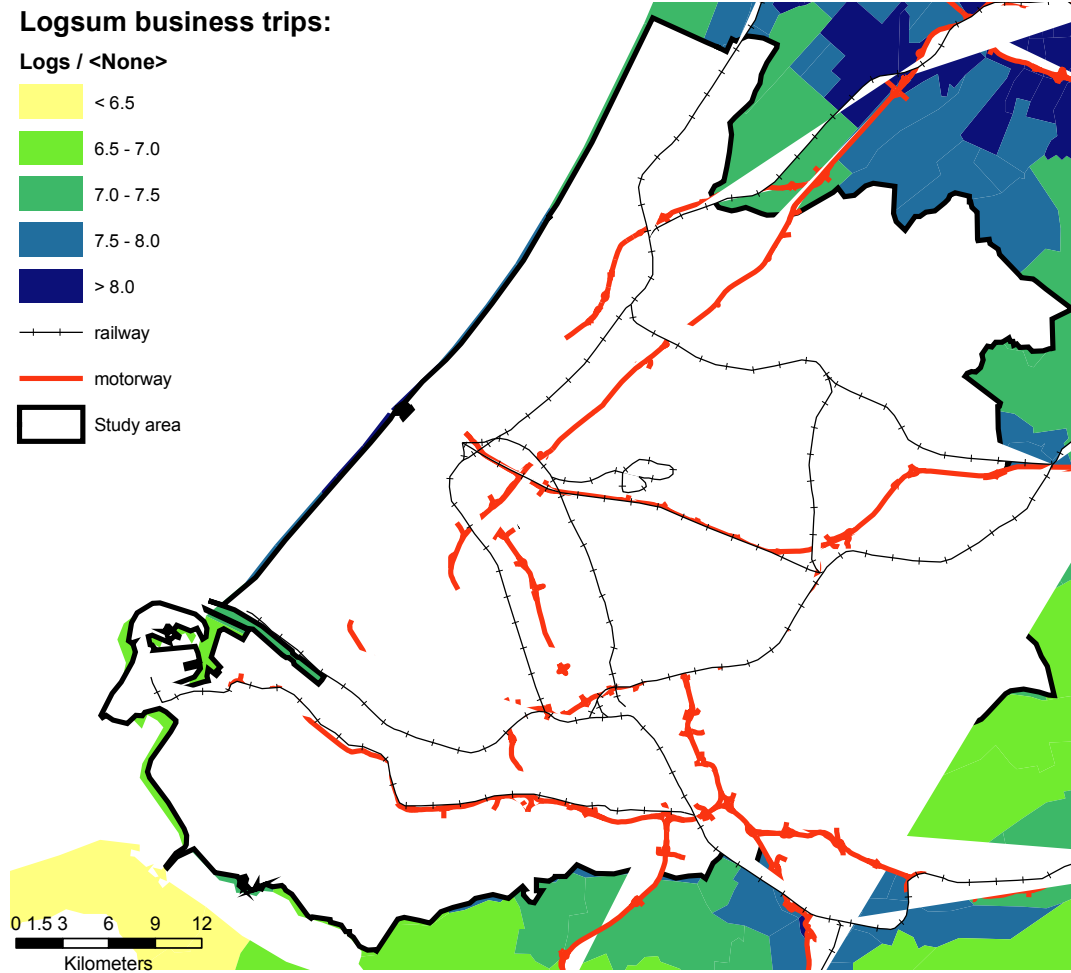
- GIS

Geographic information system, contains information on location of railways, freeways, etc.

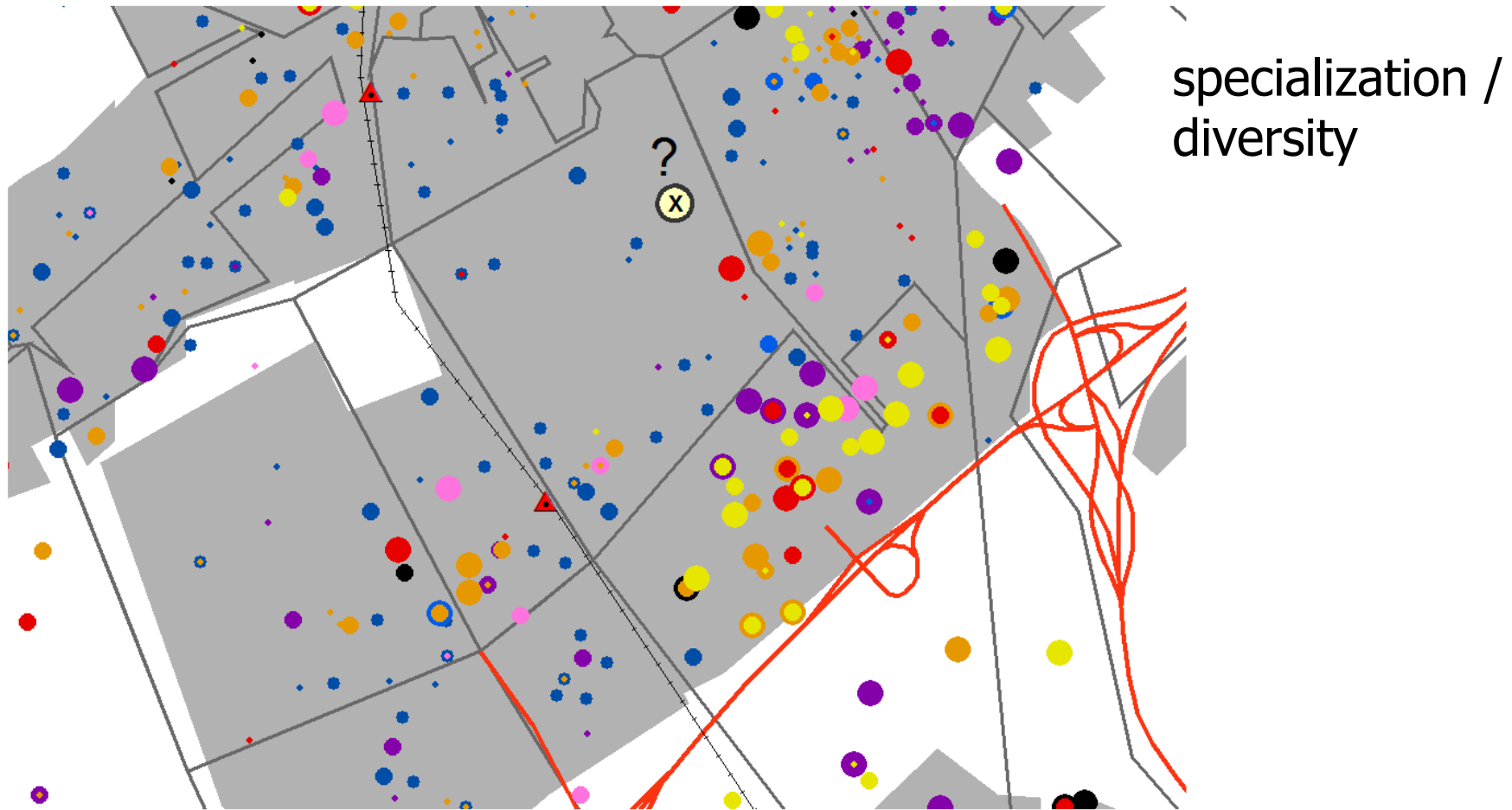
Vicinity of infrastructure



Accessibility



Neighborhood of other firms



Specialization

—+—+—+— Railway

— Highway

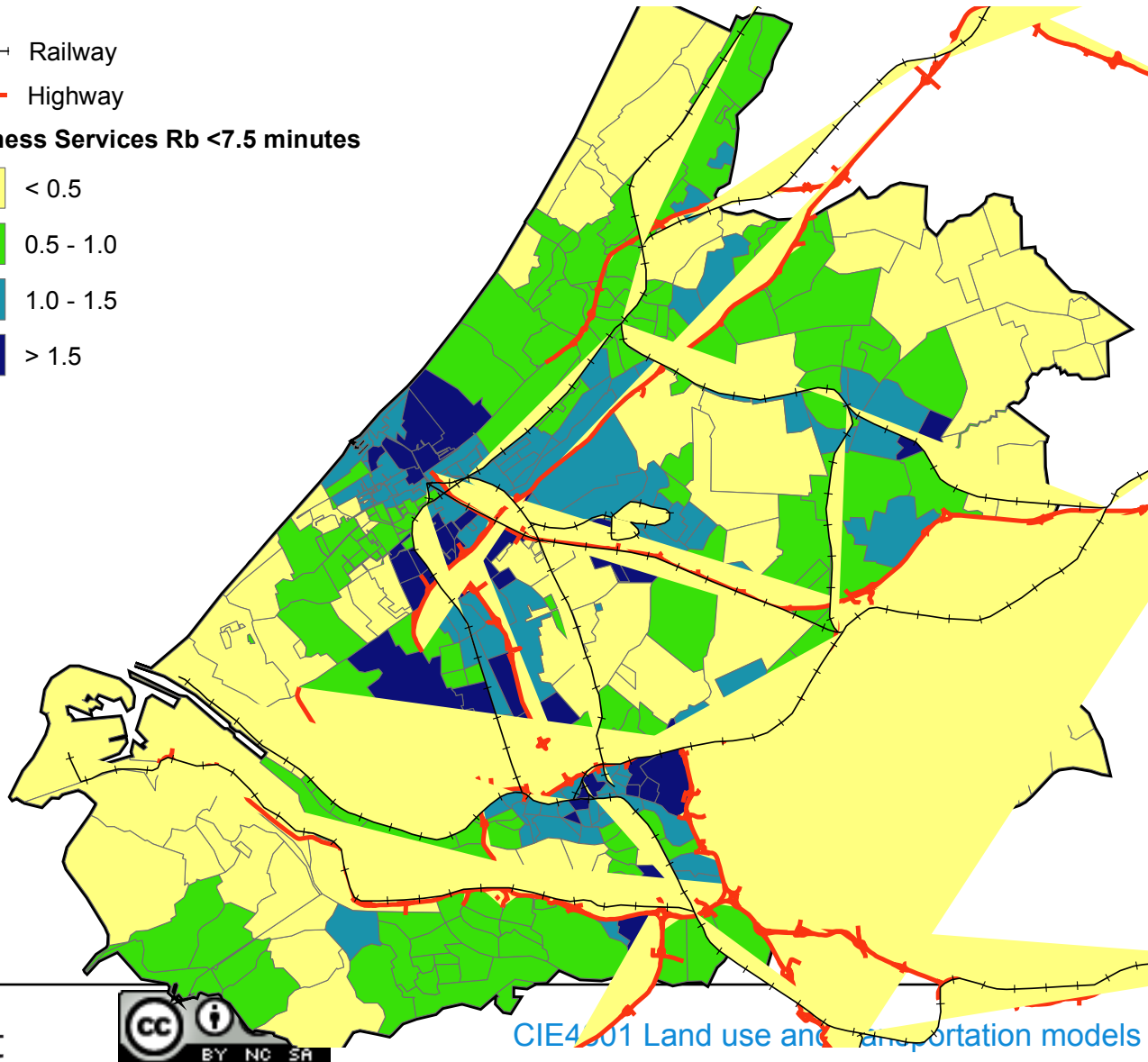
PS Business Services Rb <7.5 minutes

< 0.5

0.5 - 1.0

1.0 - 1.5

> 1.5

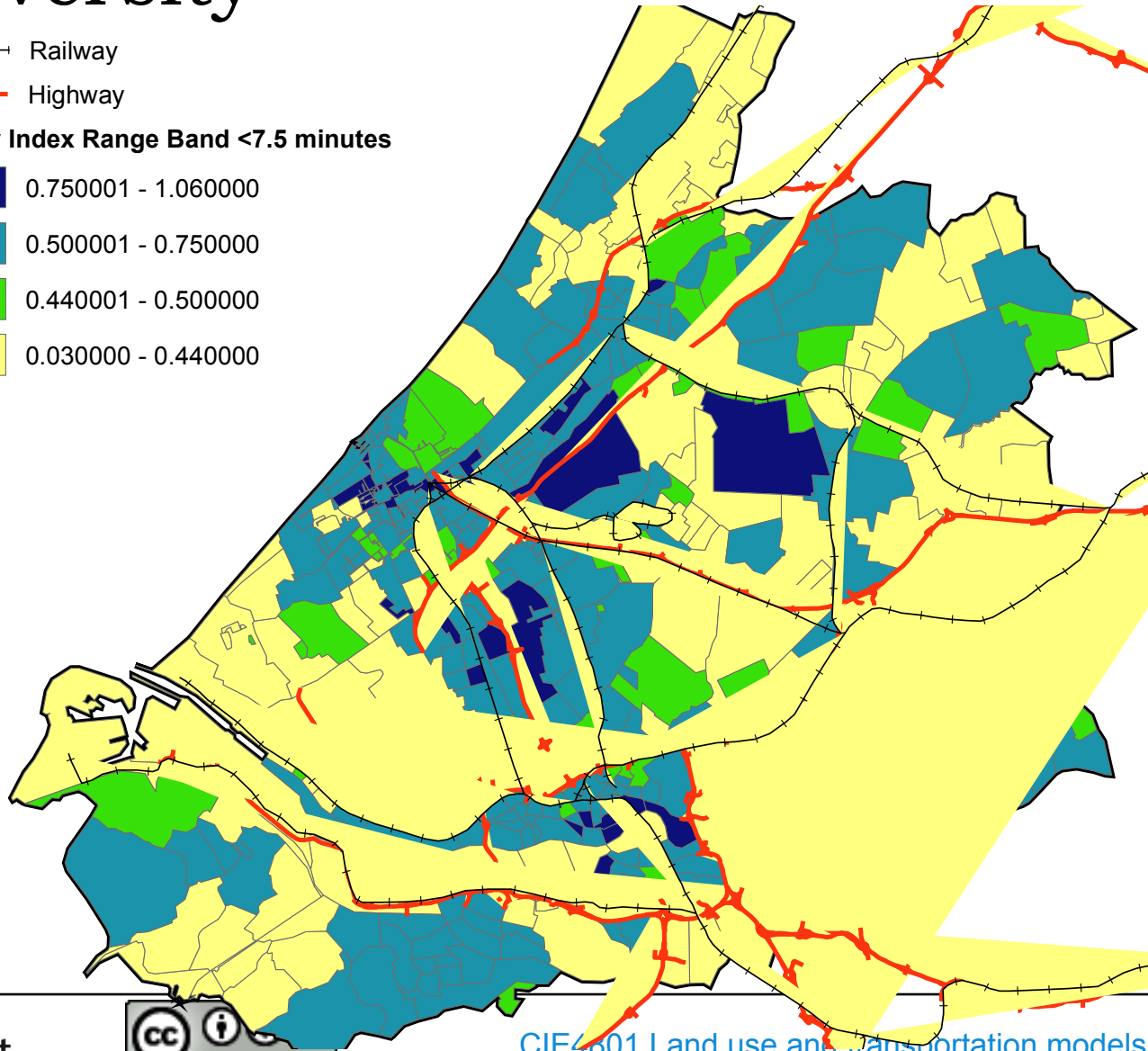
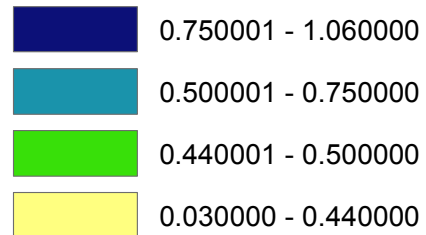


Diversity

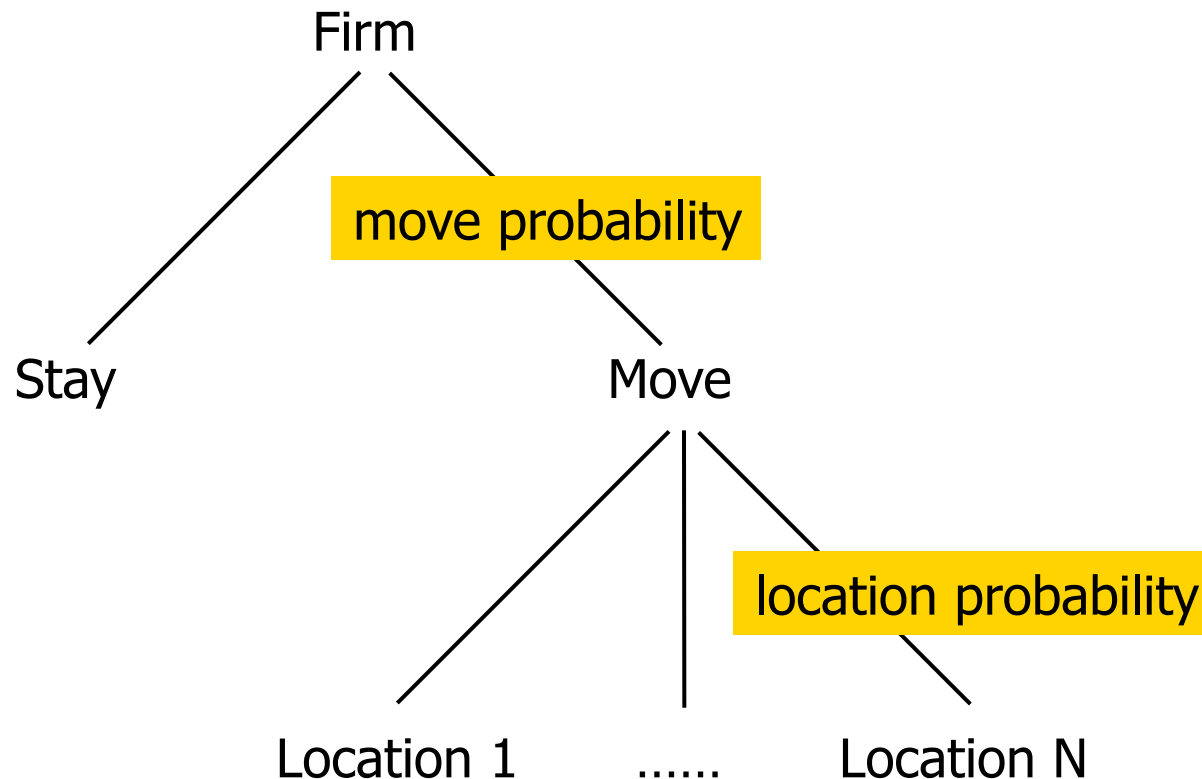
---+---+---+ Railway

— Highway

Diversity Index Range Band <7.5 minutes



Firm location choice model



Move probability

$$V_{fi}^{\text{stay}} = 0$$

$$V_{fi}^{\text{move}} = \beta_0 + \underbrace{\beta_1 Gr_f + \beta_2 (1 / Age_f)}_{\text{firm characteristics}} + \underbrace{\beta_3 Sec_f + \beta_4 Acc_i}_{\text{location characteristics}} + \dots$$

Gr = firm growth

Age = firm age

Sec = firm sector

Acc = location accessibility

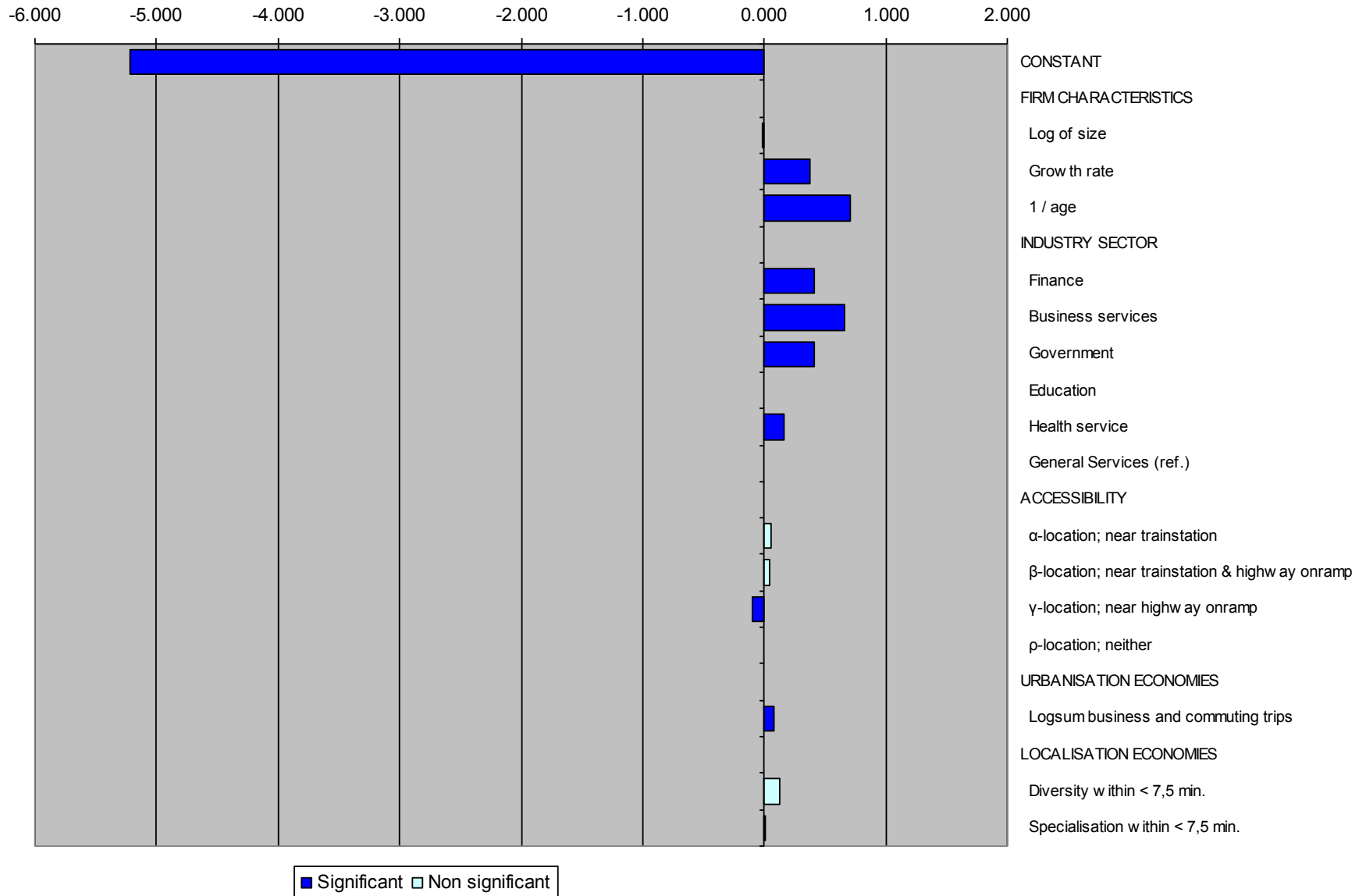
f – firm index

i – location index

$$P_{fi}^{\text{move}} = \frac{\exp(V_{fi}^{\text{move}})}{\exp(V_{fi}^{\text{move}}) + \exp(V_{fi}^{\text{stay}})} = \frac{1}{1 + \exp(-V_{fi}^{\text{move}})}$$

Move probability

Parameter estimates



Location probability

$$V_{sij}^{\text{location}} = \beta_{s1} \text{Dist}_{ij} + \beta_{s2} \text{Acc}_j + \dots$$

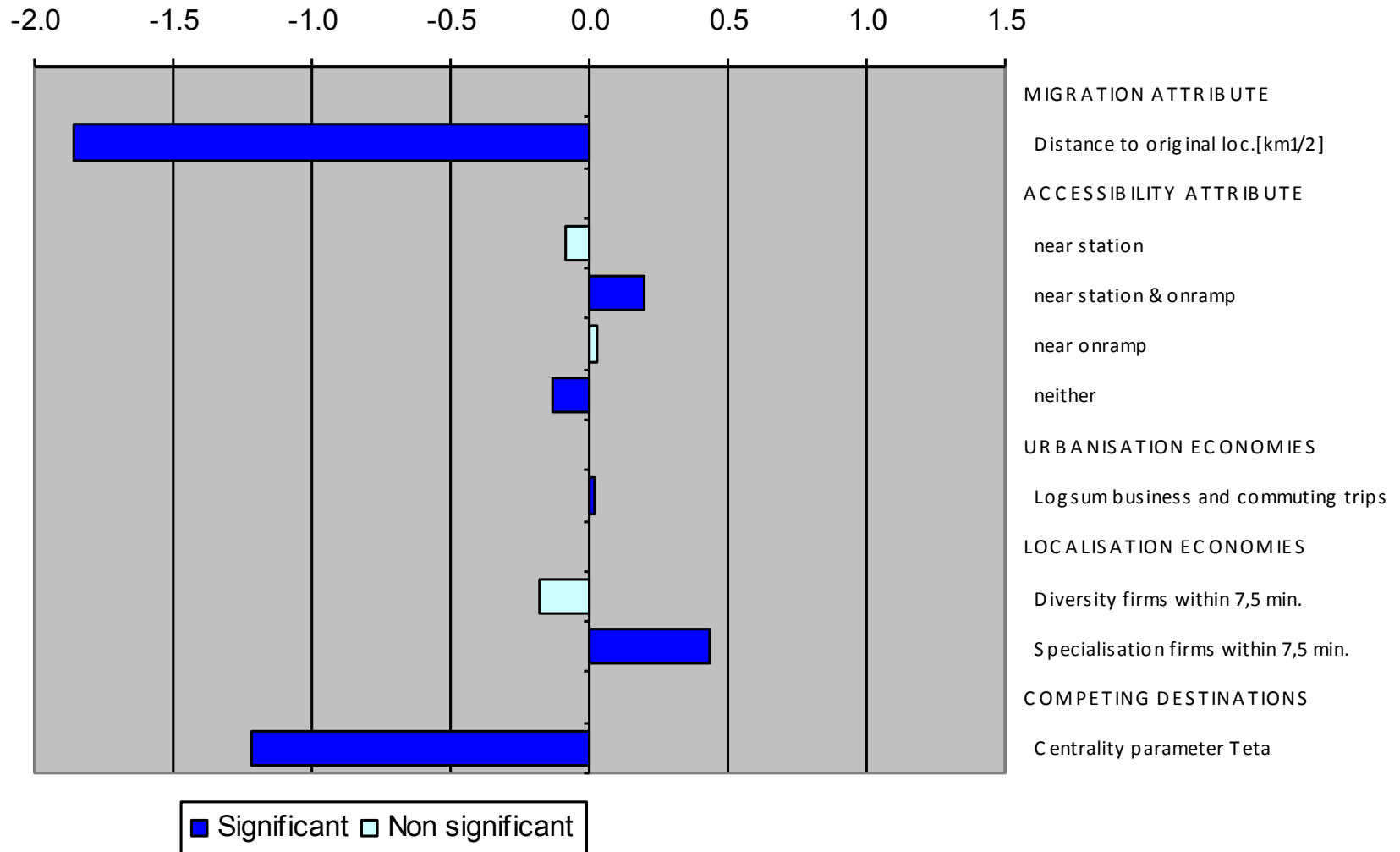
Dist = relocation distance
Acc = location accessibility

s – firm sector index
i – current location index
j – new location index

$$P_{sij}^{\text{location}} = \frac{\exp(V_{sij}^{\text{location}})}{\sum_j \exp(V_{sij}^{\text{location}})}$$

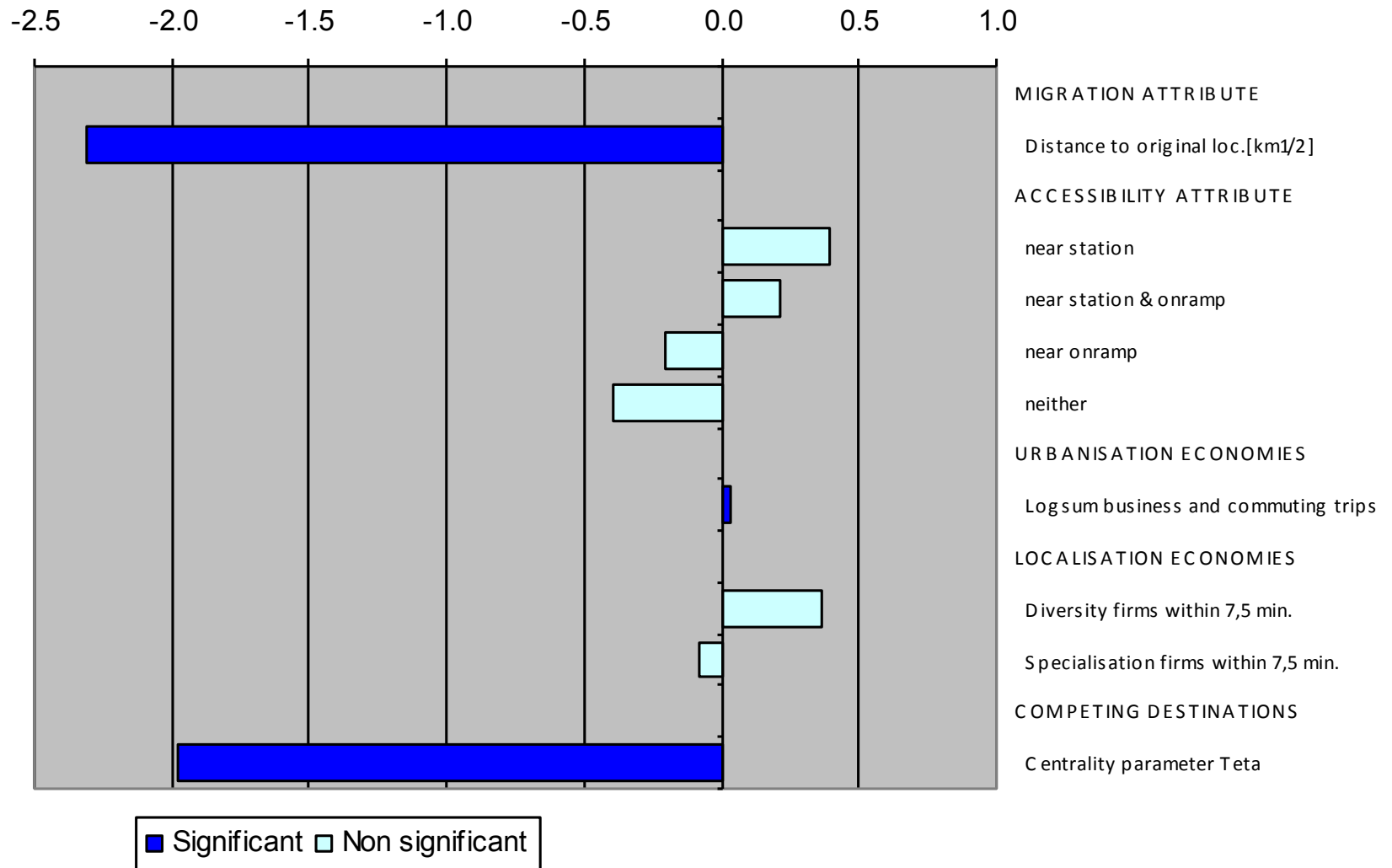
Location probability

Parameter estimates (sector Business)



Location probability

Parameter estimates (sector Finance)



Location choice companies

(result of a more recent study)

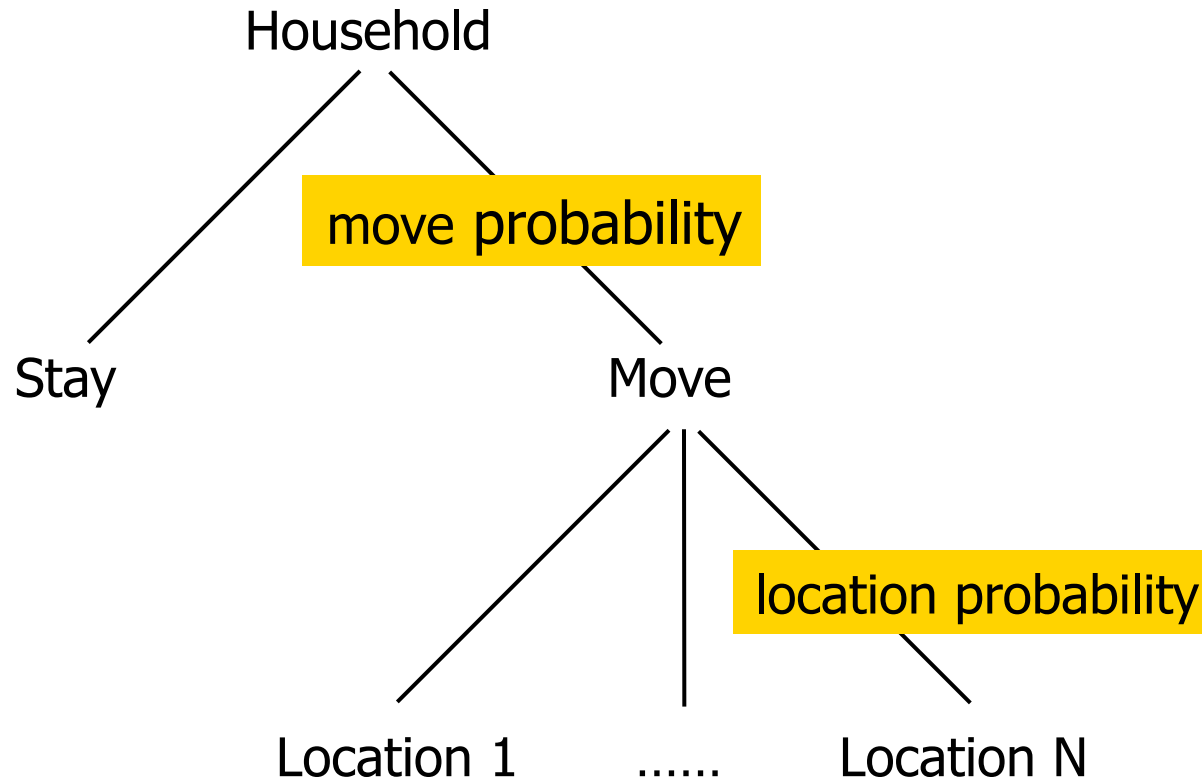
- For the choice to consider another location characteristics of companies themselves are dominant
- For the location choice accessibility attributes play a role.
- Main accessibility attributes:
 - Distance to original location
 - Distance to freeway on-/off-ramp
 - Distance to railway station
 - financing, education, catering
 - Accessibility by car
 - business, financing, manufacturing, logistics, trading and retail

M. De Bok, 2007

2.2

Choice modelling: Household location behaviour

Household location choice model



Location probability

$$V_{hij}^{\text{location}} = \beta_{h1} \text{Dist}_{ij} + \beta_{h2} \text{Acc}_j + \beta_{h3} \text{Eth}_j + \dots$$

Dist = relocation distance

Acc = location accessibility

Ethn = similarity ethnical background

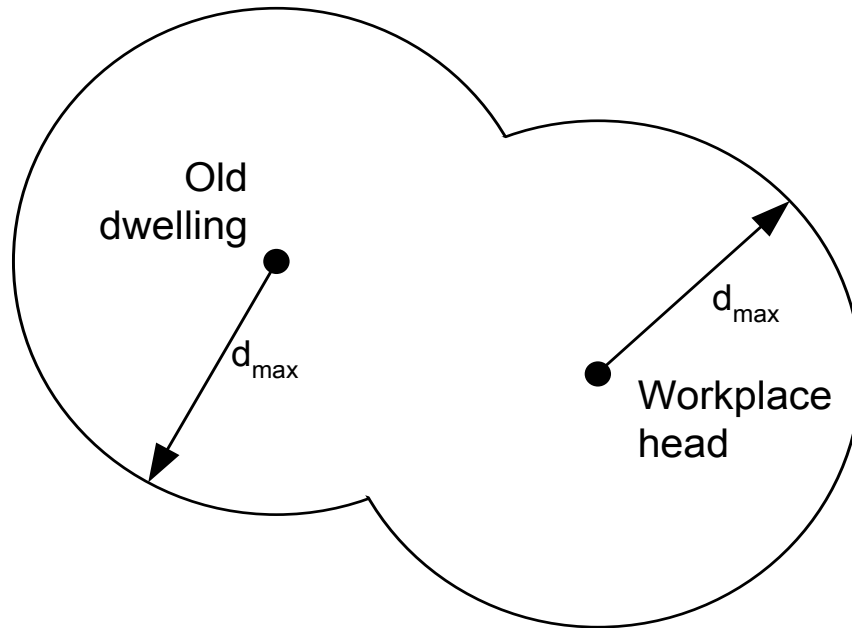
h – household type index

i – current location index

j – new location index

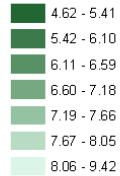
$$P_{hij}^{\text{location}} = \frac{\exp(V_{hij}^{\text{location}})}{\sum_j \exp(V_{hij}^{\text{location}})}$$

Relocation distance

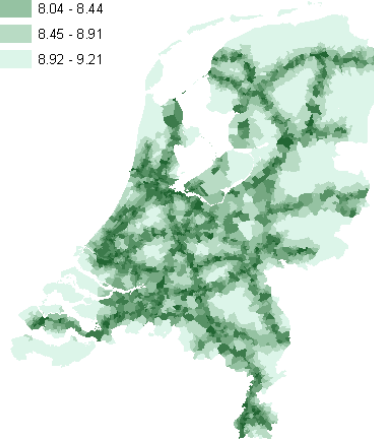
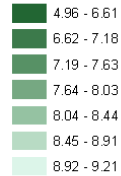


Location accessibility

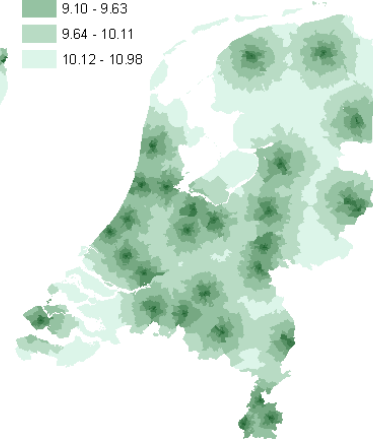
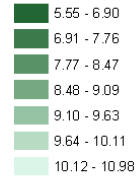
Afstand supermarkt (ln)



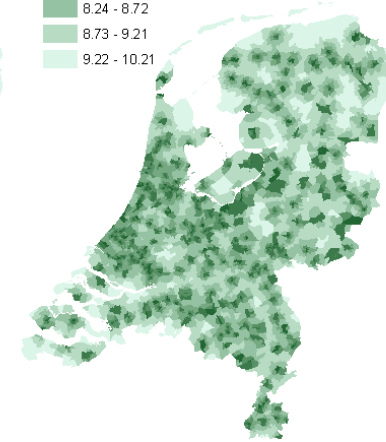
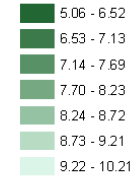
Afstand oprit (ln)



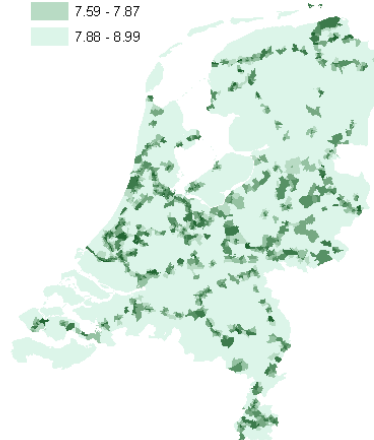
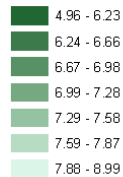
Afstand centrum grote stad (ln)



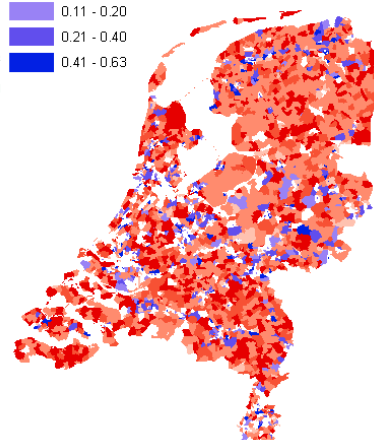
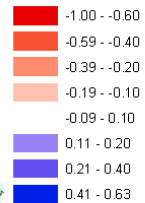
Afstand centrum kleine stad (ln)



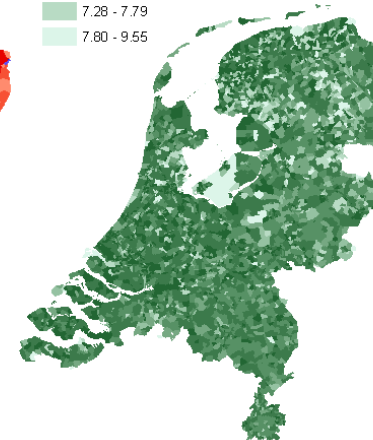
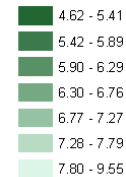
Afstand NS-station (ln)



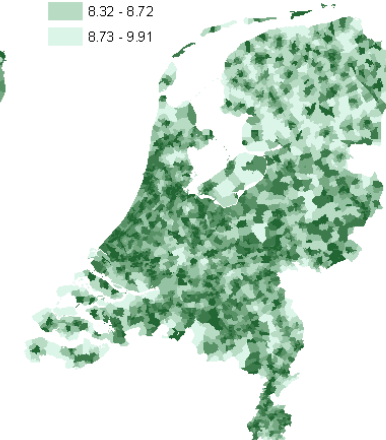
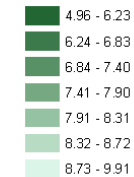
OV-kwaliteit (ln)



Afstand basisschool (ln)

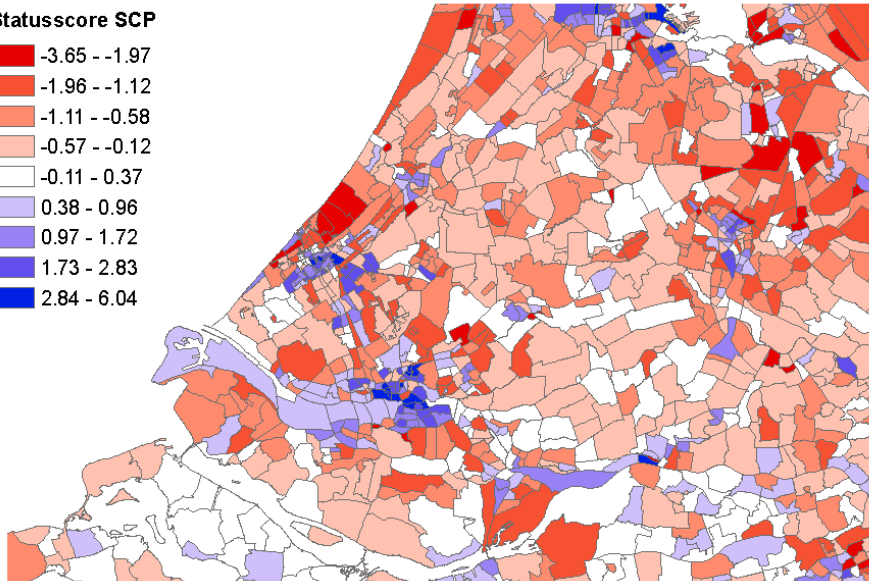
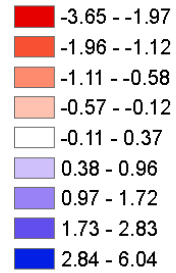


Afstand middelbare school (ln)

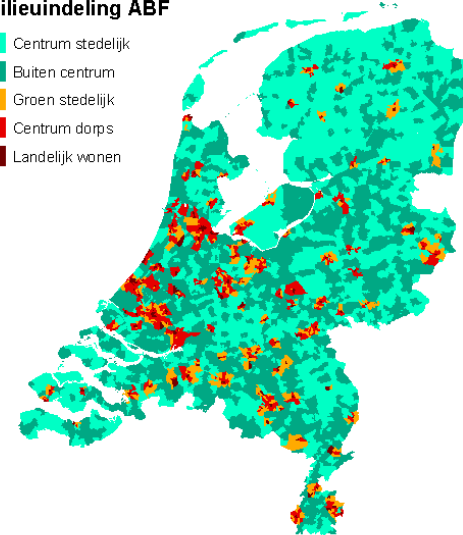


Other factors

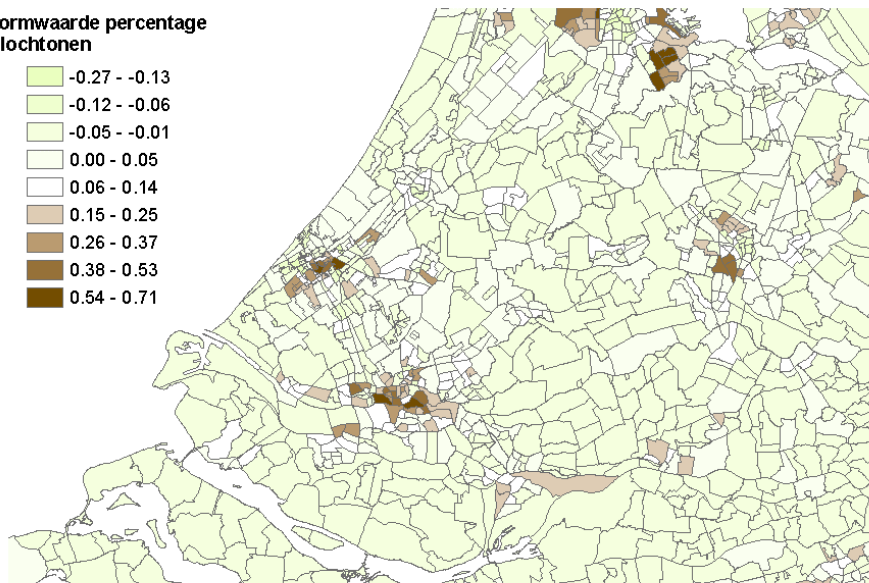
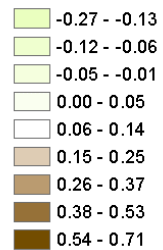
Statusscore SCP



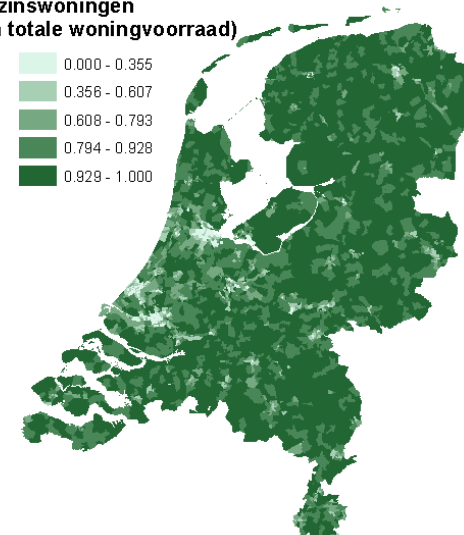
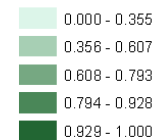
Woonmilieuindeling ABF



Normwaarde percentage allochtonen



Eengezinswoningen
(% van totale woningvoorraad)



Location choice households (result of a more recent study)

- Characteristics of house and neighbourhood are dominant
- Accessibility plays a limited role:
 - Distance to previous house
 - Distance to work by car
- More advanced modelling provides more insight
 - Distance to station (for household without a car)

B. Blijie & De Vries, 2006

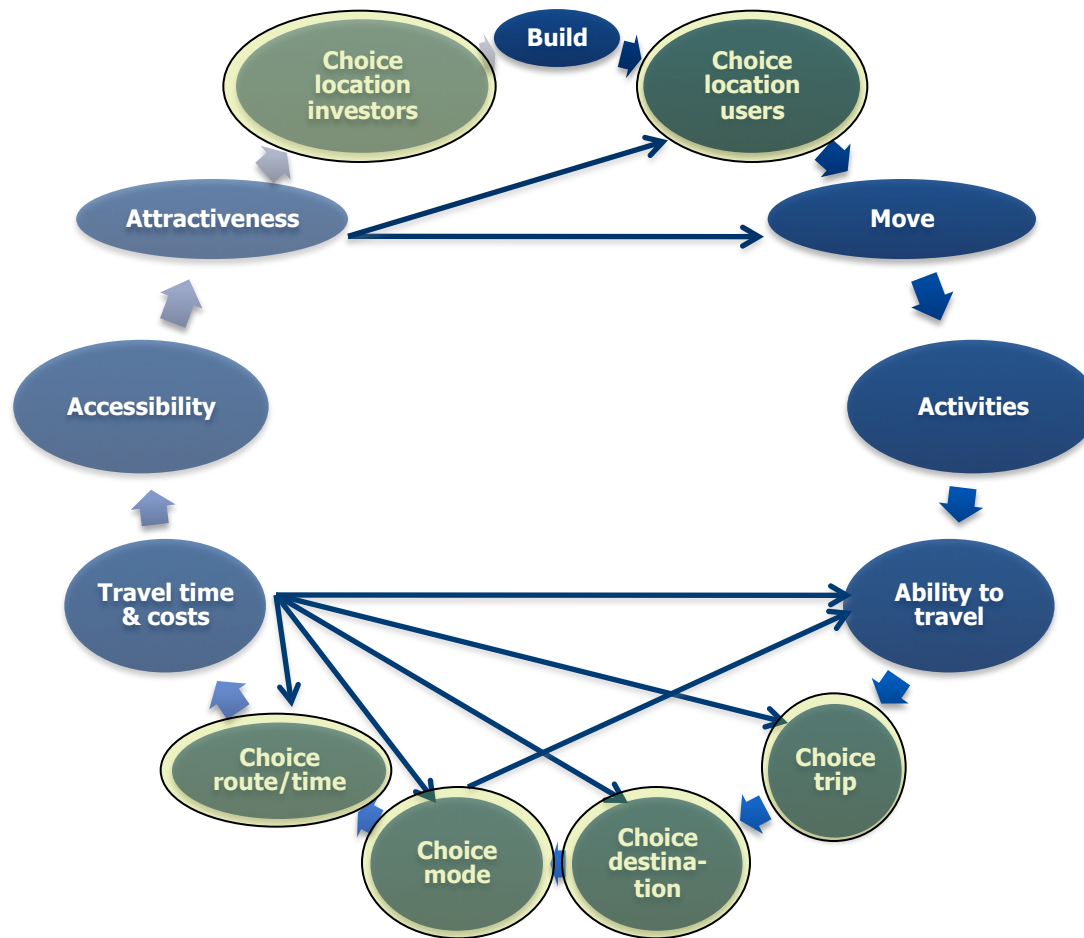
Some overall conclusions

- Shift towards disaggregated approaches (individual firms and households)
- Relocation distance is preferably small
- Accessibility plays a role in the location choice behavior
 - Accessibility is relevant for the location choice of firms, not in the decision to move
 - Best accessible locations may not be preferred by households

3.

Circle of Wegener revisited

Choice processes



Empirical evidence?

- Databases of observed behaviour
- Observed or generated choice alternatives
- Formulating choice models (logit models)
- Estimating perception factors or weights
- Resulting models of attributes having significant weights

Location choice investors

- Different decision makers thus different objectives
 - Project developers
 - Authorities
- I've got no empirical evidence for this type of choice, however...
- Given the bi-level nature of the decision problem they should consider the choice behaviour of (future) users of the location

Location choice companies

- For the choice to consider another location characteristics of companies themselves are dominant
- For the location choice accessibility attributes play a role.
- Main accessibility attributes:
 - Distance to original location
 - Distance to freeway on-/off-ramp
 - Distance to railway station
 - financing, education, catering
 - Accessibility by car
 - business, financing, manufacturing, logistics, trading and retail

M. De Bok, 2007

Location choice households

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B. Blijie & De Vries, 2006

Trip choice

- To travel or not to travel.....
- No impact of accessibility
 - Recall constant number of trips per day
- Although, for some trip purposes an effect has been found, still having a minimal impact

Willigers & De Bok, 2009

Destination choice

- Distance/time has a substantial impact: the larger the distance (or the longer the time), the lower the probability of choosing the destination (assuming similar attractiveness of the destinations)
- Car accessibility is usually dominant, except for households without a car
- Alternative modes improve accessibility, however, net impact on total attractiveness is limited

Ortúzar & Willumsen, 2001

Mode choice

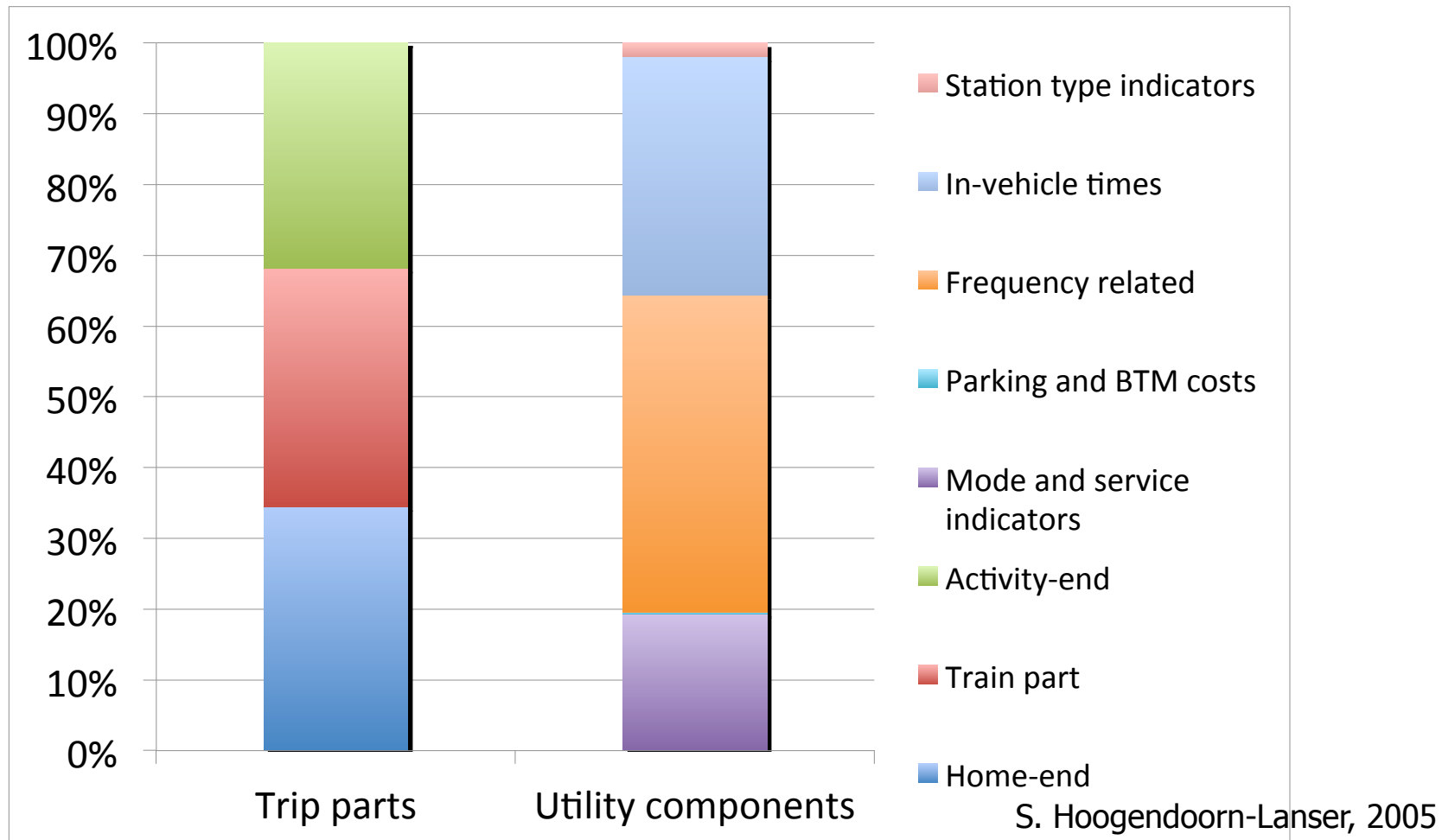
- Clear role of mode availability
 - Recall impact of 'captiveness'
- Clear role for quality (travel times) of each mode
- However, preferences for specific modes play a major role too!
 - Recall impact of 'captiveness'

Ortúzar & Willumsen, 2001

Route choice

- Clear role of travel time
- In public transport different weights for trip time elements
 - $2.2*T_a + 1.5*T_w + T_i + 2.3*T_{wt} + 5.9*N_t + 1.1*T_e$
- Train trips are in fact multi-modal (80% of train travellers uses another mode to travel to or from the station)
- Consequence of multimodality.....

Main components utility function multi-modal route choice



Conclusion

- There is empirical evidence for the mechanism in Wegener's circle
- However, in nearly every choice situation many other factors play a role, and often quite dominantly
- Often simple and more specific accessibility indicators are significant:
 - distance to former location, distance to freeway
- Mechanism is stronger for car accessibility, however:
 - Increasing car usage leads to congestion, thus making other locations more attractive