Substitutability as a spatial concept to evaluate travel alternatives

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Definition:

‘the extent to which one or multiple characteristics of the preferred travel behaviour alternative can be substituted by alternatives’

- **Activity (location)**
- **Mode**
- **Route**
- **Time**

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Related to:

- Freedom of choice
- Accessibility

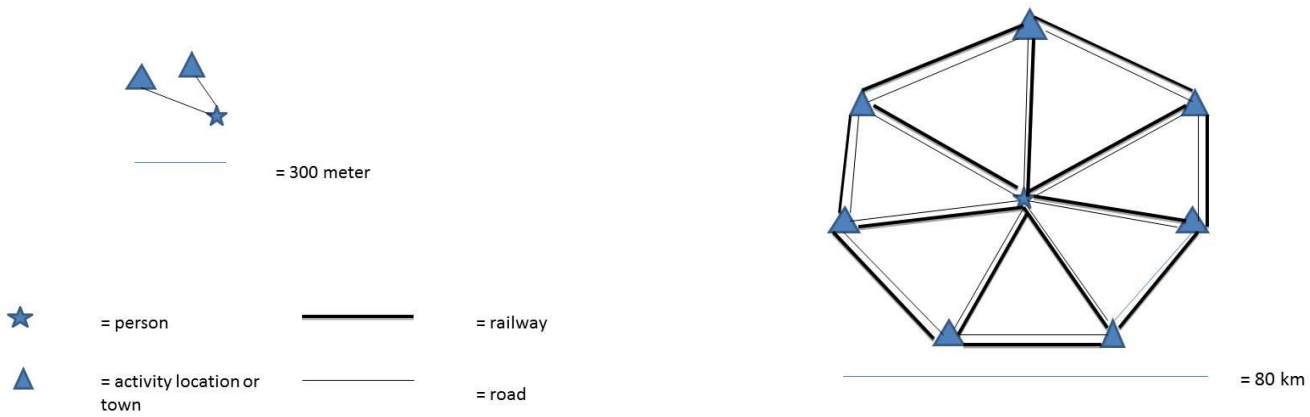
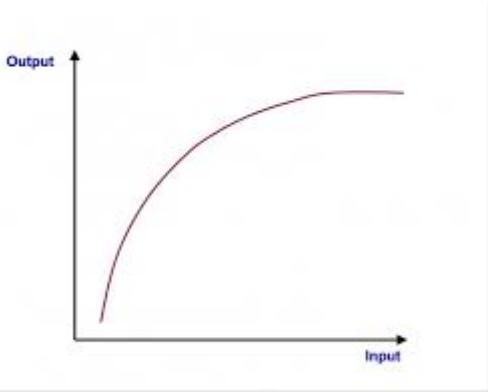


Figure 1 : Stylized example of (a) a high level of accessibility, and a low level of substitutability, and (b) a low level of accessibility and a high level of substitutability.

Relevant for conceptualization:

- Gradual concept
- Normalized or not?
- Additional value of additional options
  – Diminishing



Relevant for conceptualization:

- Overlap
- Individual versus social choices
- Pre trip, on trip, during activity program
- Return trip: limitations

Aggregation level of the level of substitution.

We distinguish:

1. Components of trips for one person
2. A full trip or activity for one person
3. A cluster of activities/ trips for one person
4. An aggregation of the three levels above, but now for a group of persons
5. The perspective of the origin or destination of the trip

Mathematics

Multiple options. Our choice:

- **Higher values of indicator: higher levels of substitution**
- **Normalized between 0 and 1**
- **Logsum based**

- **Multiple formula tested – (best) one presented**

Mathematics - proposal: Logsum based

$$LS_n = \ln\left(\sum_j e^{V_{jn}}\right) + C$$

Relative decrease without best alternative(s)

$$S_n = \frac{1}{LS - LS^{Y=i}}$$	(equation 2)

Includes uncertainty / probabilities

$$S_n = \frac{1}{LS - \sum_{i=1..J} P_i \cdot LS^{Y=i}}$$	(equation 3)

Normalize between 0 and 1

$$\hat{S}_n = 1 - \frac{1}{1 + S_n}$$

Application

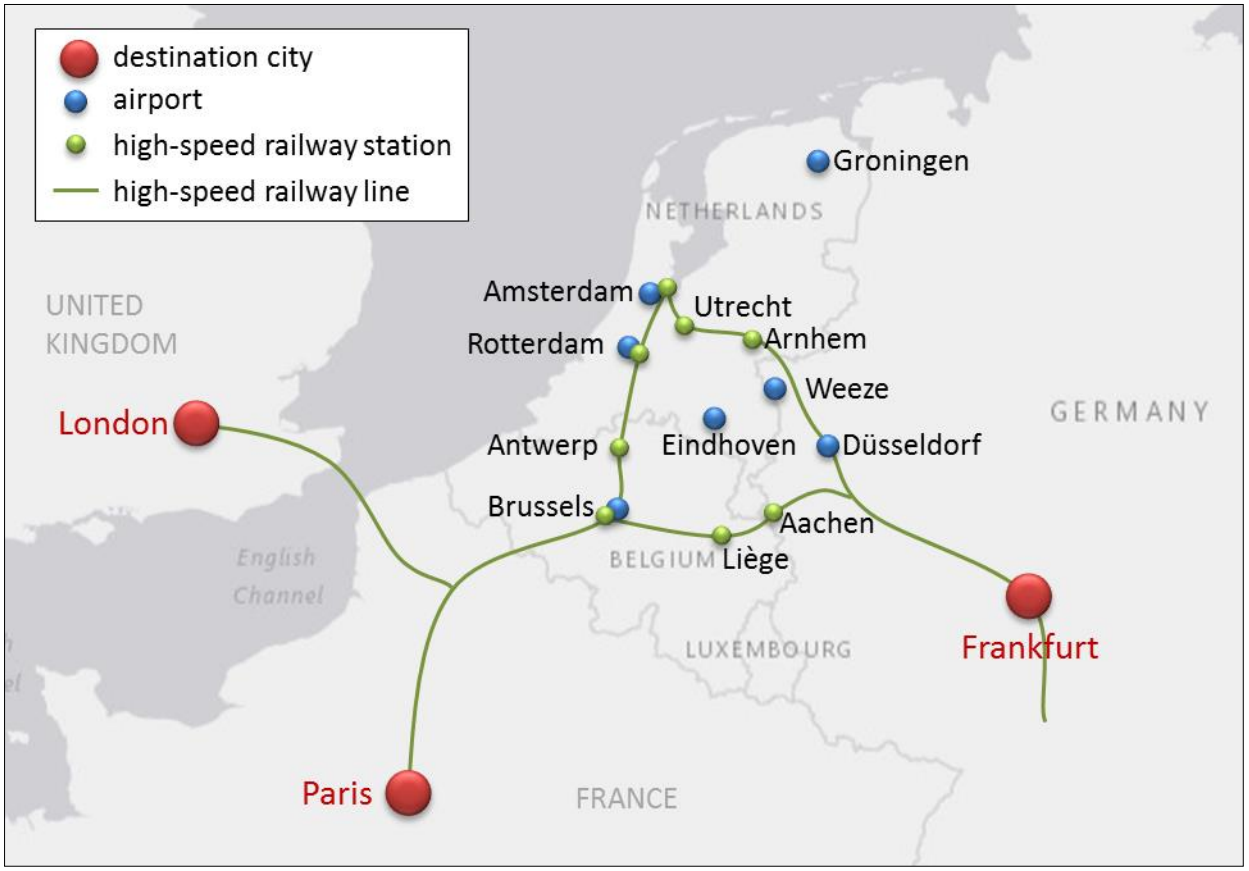


Figure 3 Logsum and substitutability by air, with driving as access mode

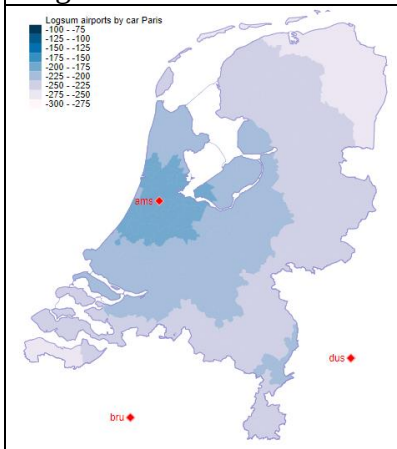
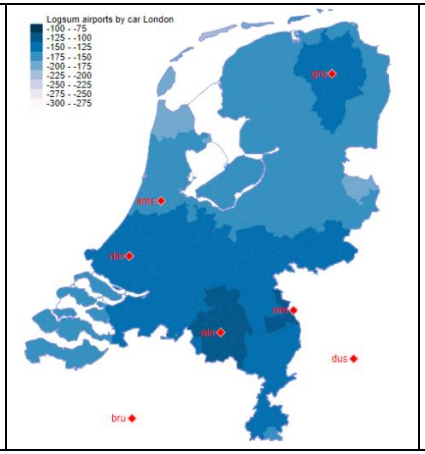
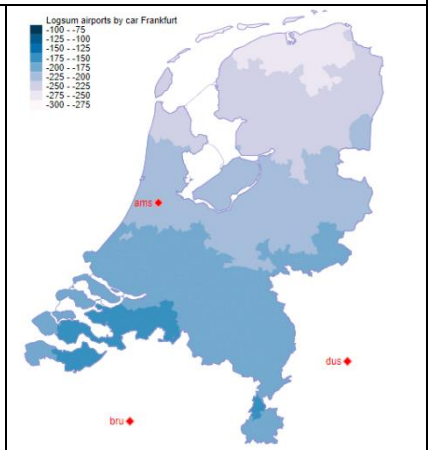
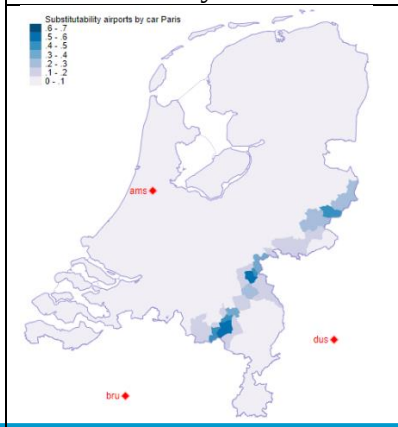
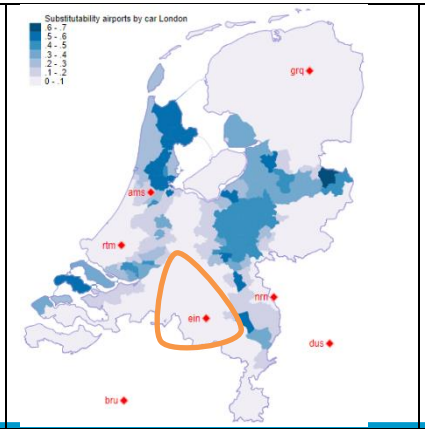
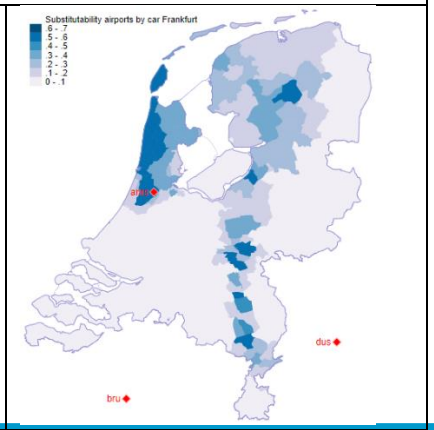
Paris	London	Frankfurt
Logsum		
		
Substitutability		
		

Figure 5 Logsum and substitutability by air and high-speed rail, with driving as access mode

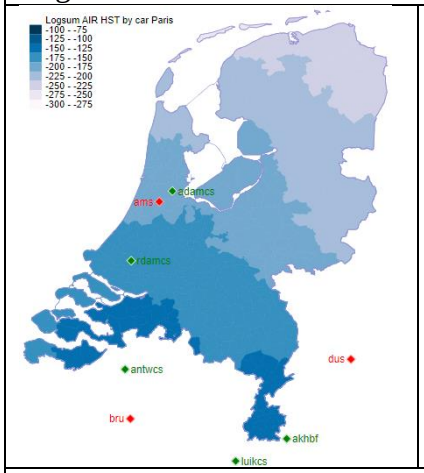
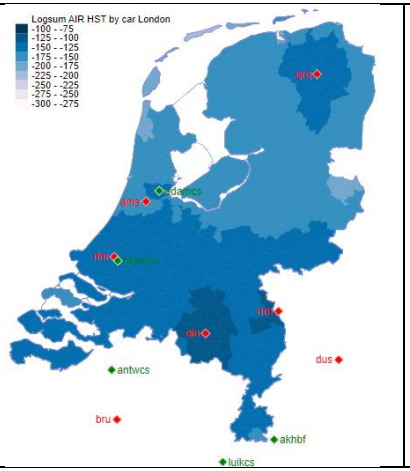
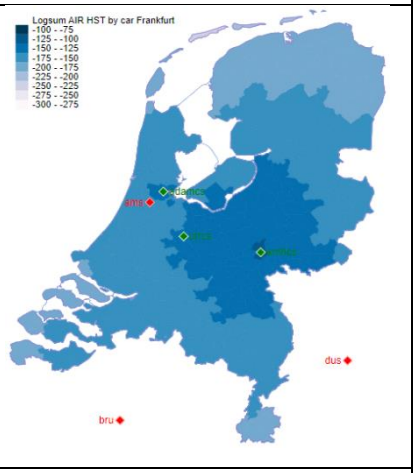
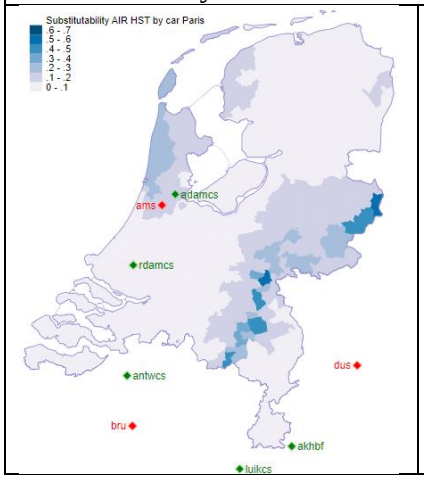
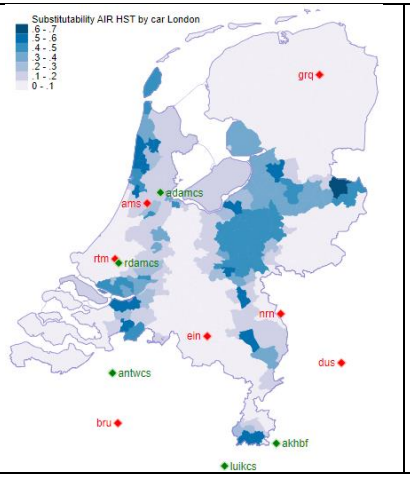
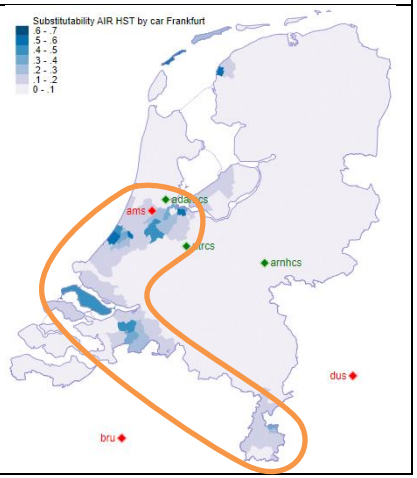
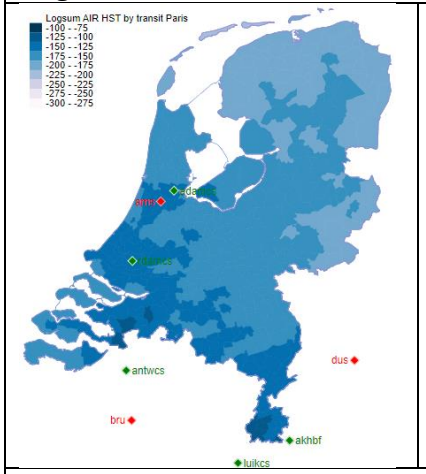
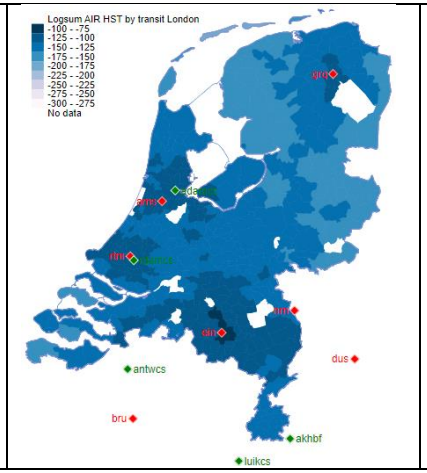
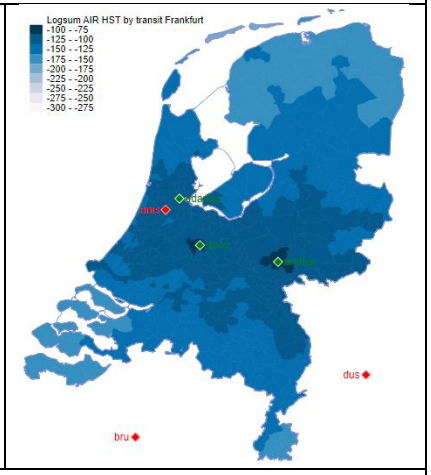
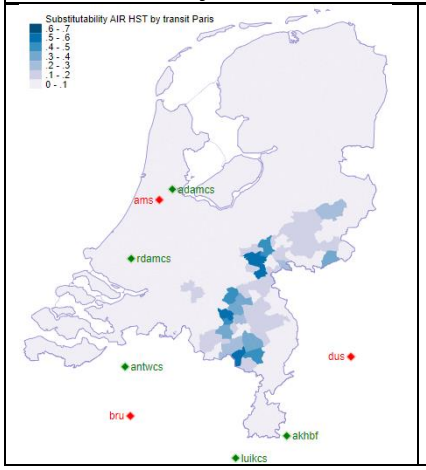
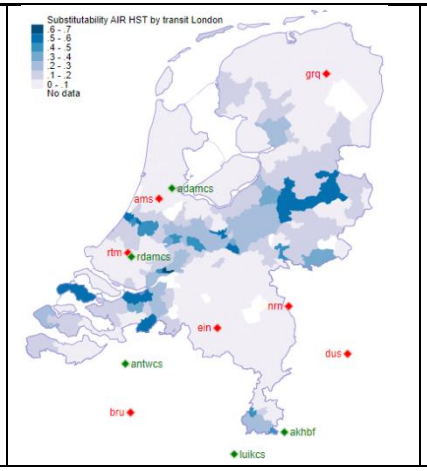
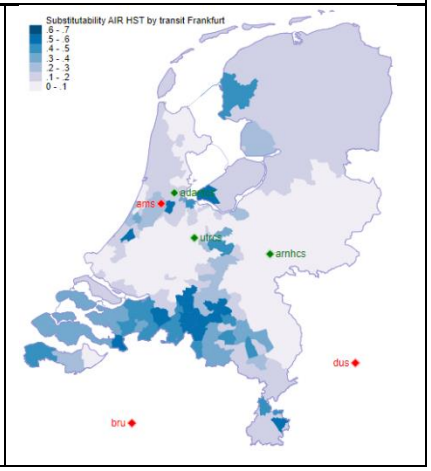
Paris	London	Frankfurt
Logsum		
		
Substitutability		
		

Figure 4 Logsum and substitutability by air and high-speed rail, with public transport as access mode

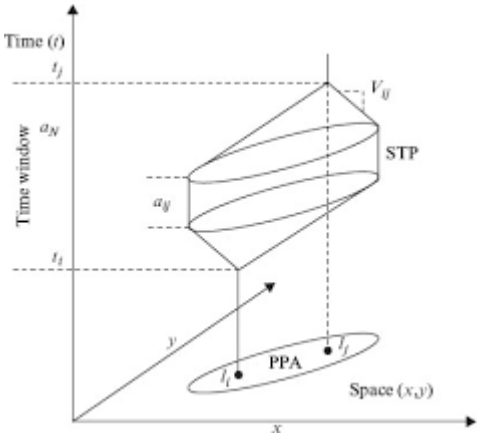
Paris	London	Frankfurt
Logsum		
		
Substitutability		
		

Conclusions case study

- **Doable!**
- **Results not immediately intuitive, but can be explained**
- **Substitutability not comparable to Logsum accessibility**

Research agenda:

- Alternative formula
- Methodology disentangling contributions of components of LU and Transport system
- Empirical research: perceptions substitutability
- Role of constraints
- Role of ICT



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- Interactions between dimensions (e.g. transport and land use)
- Implications for modelling
- What do clients want?
- Link with evaluation frameworks

- Policy implications

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Concluding remarks

- Goods transport
- More than transport