Identification and Classification of Urban Centers based on Public Transport Passenger Flows Data

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Measuring urban activity centers

- What are the main urban activity centers?
- What is the spatial and temporal distribution of activities?
- How can the centers be classified based on their functions?

- Support evidence-based spatial planning
- Assess diversion from planning policies

- **Morphological** methods
  - land-use/network densities as proxies

- **Functional** methods
  - travel habit surveys

- Heavily focus on employment/commuting
- Lack of a systematic method classification
Analysis approach

Identification

Classification

Stops

Clusters

Classes

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Identification method

- Group *member* stations to the closest *cluster-centre* station which dominates the cluster in terms of passenger *flows*, while not exceeding a maximum *distance*.

- Using total daily incoming and outgoing flows.

- Not exhaustive; share of flows as a stopping criterion.

- A sensitivity analysis to test partition consistency.
Classification method

- Calculating cluster dissimilarity
  \[ d_{cm,cn} = \sum_t |y_{m,t} - y_{n,t}| \]

- Create a hierarchical tree based on the distance function

- Partition clusters based by minimizing intra-cluster variations and maximizing inter-cluster variations

- Assess the quality of the partitioning
  \[ d_{intra} = \sum_{u_k \in U} \sum_t |y_{m,t} - y_{n,t}| \]
  \[ d_{inter} = \sum_{u_k,u_l \in U} \sum_t |y_{m,t} - y_{n,t}| \]
The case of Stockholm

- Stockholm metropolitan area (~Stockholm County)
- 26 municipalities, 6500 km², 2.16 m
A shift in planning policy

Data

- Boarding and alighting flows per station for all PT modes by time-of-day for 12,757 stops in 2011-2012

- Primary travel mode: 54% of all trips by PT, 80% for trips destined in the regional core, 0.63 trips per day per per.
Sensitivity to clustering parameters

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CDF of clustered-flows

Marginal share of the flows assigned to clusters

Clusters

1  3  5  7  9  11  13  15  17  19  21  23  25  27  29  31  33  35  37  39  41  43  45  47

R=1km Threshold=0.5  R=1km Threshold=0.6  R=1km Threshold=0.7

R=2km Threshold=0.5  R=2km Threshold=0.6  R=2km Threshold=0.7

R=3km Threshold=0.5  R=3km Threshold=0.6  R=3km Threshold=0.7

R=4km Threshold=0.5  R=4km Threshold=0.6  R=4km Threshold=0.7

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Radius = 1.5 km, Threshold = 60%
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Classification indicators

- **A+B**: Total flow magnitude, 'center size'
  \[ f_{m,t}^a + f_{m,t}^b \]

- **A-B**: Centre attraction (net inflow)
  \[ f_{m,t}^a - f_{m,t}^b \]

- **(A-B)/(A+B)**: Relative attraction (-1 source-sink +1 roles)
  \[ (f_{m,t}^a - f_{m,t}^b)/(f_{m,t}^a + f_{m,t}^b) \]
Hierarchical clustering trees (dendrogram)
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(A-B)/(A+B)
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Has Stockholm grown polycentric?

- Multi-centric: the geographical and planning context facilitated the generation of a relatively large number of sub-centers
- More functionally multi-centric than morphologically

- The regional core still dominates
- **Specialized secondary sub-centers**: attractors of a secondary order beyond the inner-city
- **Expending beyond the waterways**: Balanced-flows in the south edges of the inner-city
- Other ‘sub-centers’
  - insofar remain ‘bedroom suburbs’ or negligible
Conclusion

- An integrated method for identifying and classifying urban activity centers based on transport flows data

- Functional-movements; morphological-no interactions; temporal profiles, pervasive data collection

- OD flows rather than incoming and outgoing, multi-modal

- Could be especially useful for mega-cities in emerging economies, urban structure evolution