5th INTERNATIONAL SYMPOSIUM ON HIGH-SPEED RAIL SOCIOECONOMIC IMPACTS

Beyond the station:

The impact of first and last mile on perceived accessibility in high-speed rail travel

Emanuela Montenegro[1], *Mario Tartaglia*[2],
Martina Farsi[2]
[1]University of Bari Aldo Moro; [2]Ferrovie dello Stato Italiane

10th September 2025

Index

Introduction and objectives

- High-speed rail is often associated with improvements in accessibility (the ease of reaching places and opportunities), usually measured through on-board travel time alone.
- Tartaglia et al. (2023) developed a user-based accessibility model that also incorporates service availability, waiting times, and the number of transfers, which is updated (for the year 2019) in the present study by considering:

access and egress times between HSR stations and functional urban centroids

Objectives:

1.
Evaluate the **implications** of including in the original model access and egress in the measurement of accessibility

2.
Investigate how accounting for access and egress times **alters the comparative accessibility advantage** across different types of Italian cities

Gruppo FS
FS Research Centre
Il Centro Studi di Ferrovie dello Stato Italiane
UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

Background

Accessibility and first and last mile

- Considering access and egress times helps quantify the influence of the station’s urban context on HSR accessibility.
- These segments:
  - ➢ May represent **up to 55% of total travel time** [1], significantly affecting user satisfaction;
  - ➢ Vary according to the station’s location (central vs. peripheral), the congestion levels and the transport mode used to reach or leave the station (car/taxi, public transport, bike or walking).
- As spatial anchors for origin and destination a user perspective focused on knowledge workers is adopted, using functional centroids based on high-knowledge activity concentrations [2, 3]:
  - → because HSR impacts are most significant in **service-oriented** and **knowledge-intensive sectors**, due to their dependence on skilled labour, face-to-face interactions, and rapid information flows.

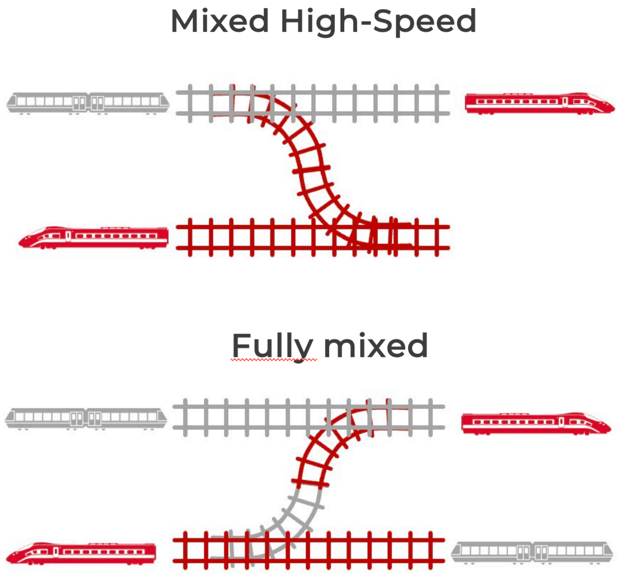
Sources: [1] Moyano et al. (2018). *Access and egress times to high-speed rail stations: A spatiotemporal accessibility analysis*; [2] Chen (2014). *Impacts of French High-Speed Rail Investment on Urban Agglomeration Economies*; [3] Cheng et al. (2015), *High-speed rail networks, economic integration and regional specialization in China and Europe.*

Background

The Italian high-speed rail system

Network characteristics:

- The Italian HSR system is closer to the French model (**mixed high-speed model**): dedicated passenger lines operating up to 300 km/h on high-speed corridors and 200–250 km/h on upgraded conventional sections.
- It also incorporates some elements of the German model (**fully-mixed model**): some corridors conceived as 'high-capacity' (AV/AC), theoretically also open to freight.



Main stages

1975 – Construction begins on Florence-Rome "Direttissima"
1992 – Inauguration of the Florence-Rome HSR line
2005–2009 – Major expansion phase: Roma-Napoli, Milano-Bologna, Torino-Milano
2012 – Market liberalisation with NTV (Italo), first private HSR operator in Europe
2013 – Reggio Emilia Mediopadana station opens
2017 – Napoli Afragola station opens

Methodology

Calculation of access / egress times

Main steps:

1. Sample of 71 cities with stations served by at least one Frecciarossa or Frecciargento service in 2019.
2. Calculation of the coordinates of the stations and the 'functional' centroids with Open Street Map (OSM): one or more centroids depending on the city population (threshold of 500K inhabitants).
3. Calculation of the access and egress time between each station and the functional centroid of the city with Google Maps API in 4 scenarios: car during peak (8-9 am) and peak-off hours (2-3 pm), bicycle and walking.

Methodology

Functional centroids

- Ideally, functional centroids could be built from sub-municipal ATECO employment data, but ISTAT's post-2011 censuses lack the required granularity.
- **Alternative method: OSM-based Functional Centroids**

  Extraction of high-knowledge activity points from OSM:

  - ➢ Use of selected labels as proxies for knowledge-intensive functions:

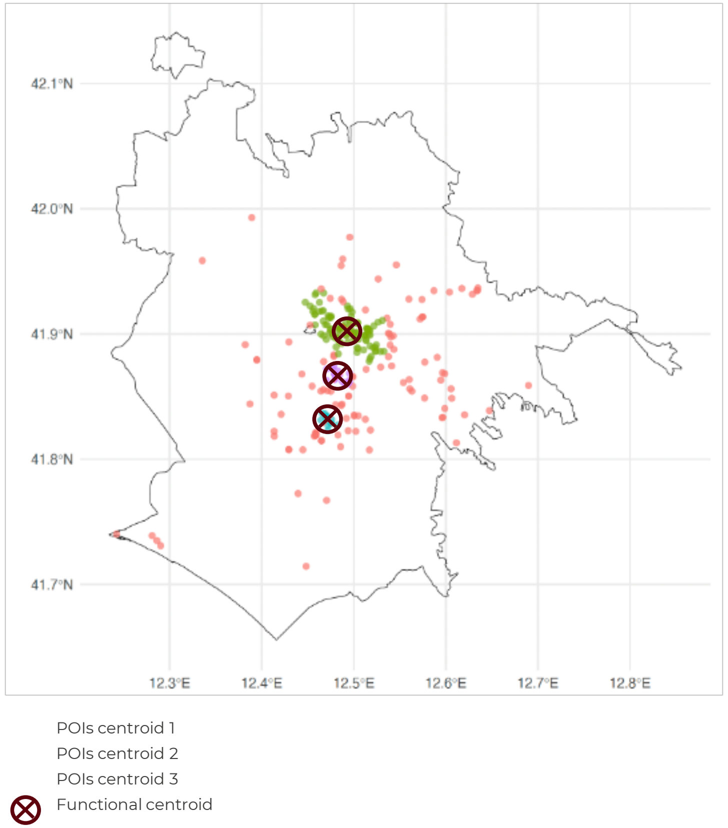
consulting, engineer, architect, research, laboratory, startup, incubator, university, college, software, tech, it, financial, company, corporate, business_centre, coworking, conference_centre, expo_centre, advertising, marketing (queried across: office, amenity, shop – within municipal boundaries*)*

  - ➢ Due to the lack of complete historical POI data for 2019, we rely on the 2025 dataset as a static proxy, given the relative spatial and functional stability of such activities.

Methodology

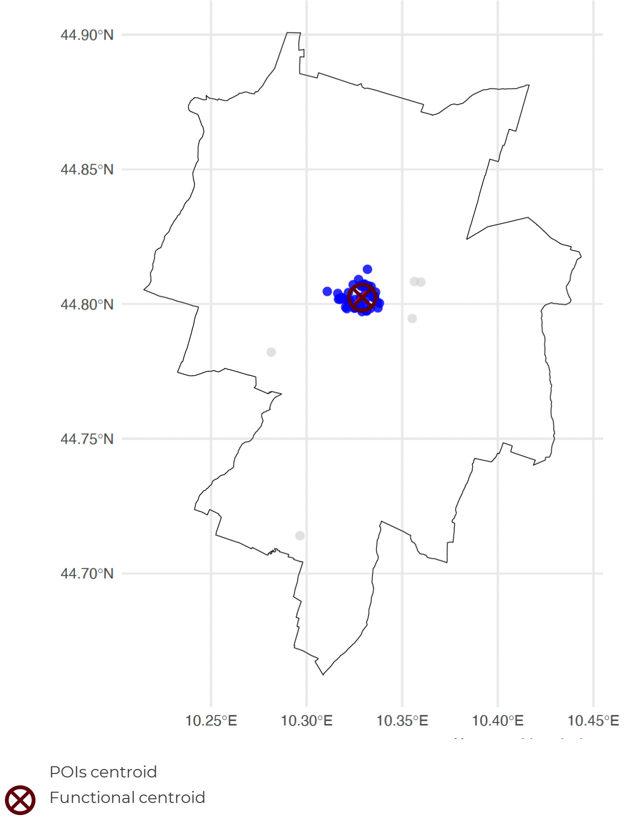
Coordinates of functional centroids

City population >500K



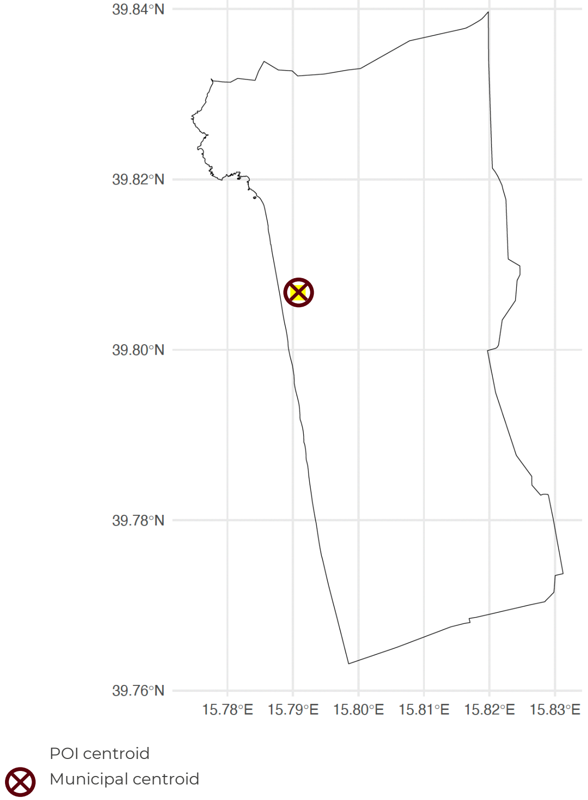
All identified functional centroids are considered in the analysis

City population <500K



Only one functional centroid is considered in the analysis

City population <500K and NO POI

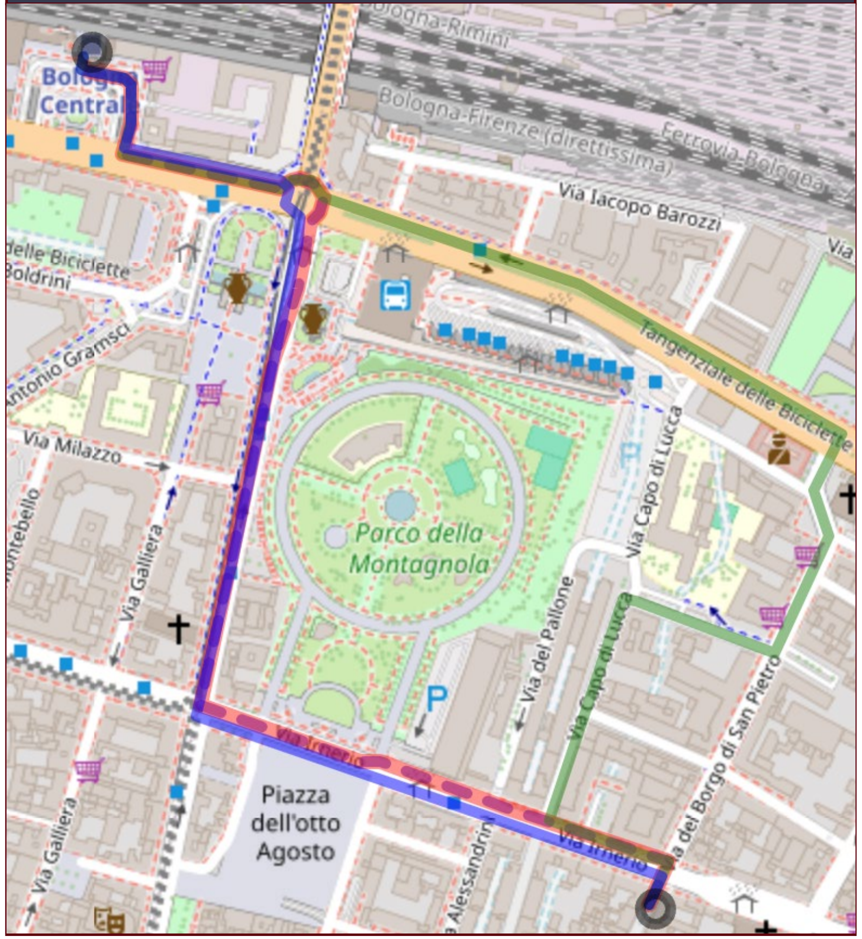


The functional centroid corresponds to the town hall

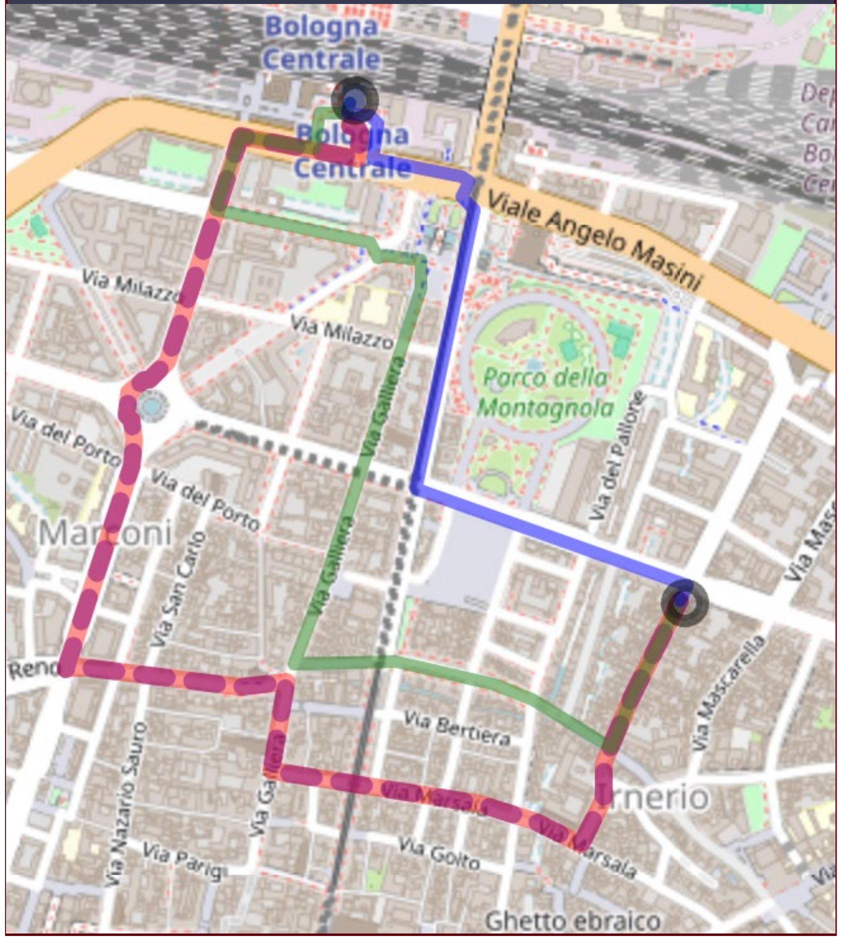
Methodology

Modes of transport considered for access/egress times

Access (e.g . Bologna)



Egress (e.g. Bologna)



Access and egress paths

- car peak hours
- car peak-off hours
- bicycle
- walking

Gruppo FS

FS Research Centre
Il Centro Studi di Ferrovie dello Stato Italiane

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

Methodology

Analysis of accessibility change due to access/egress time inclusion

- Total travel times are calculated:

access time
(centroid → HSR station)

rail travel and
waiting time
(from PTV-Visum)

egress time
(HSR station → centroid)

- Destination reachability within 120, 180, and 240 minutes is reassessed for the four urban transport modes;
- For each city and scenario, a **composite indicator** measures accessibility change compared to the previous study:

$$Accessibility\ change = 0{,}6 \cdot \frac{S_{ass} - min(S_{ass})}{max(S_{ass}) - min(S_{ass})} + 0{,}4 \cdot \frac{S_{rel} - min(S_{rel})}{max(S_{rel}) - min(S_{rel})}$$

where:

$$S_{ass} = \frac{3 \cdot A_{120} + 2 \cdot A_{180} + 1 \cdot A_{240}}{6}, \ S_{rel} = \frac{3 \cdot R_{120} + 2 \cdot R_{180} + 1 \cdot R_{240}}{6}$$

and: S_{ass} = absolute change score
A_x = absolute change at the x-minute thresholds
S_{rel} = relative change score
R_x = relative change at the x-minute thresholds

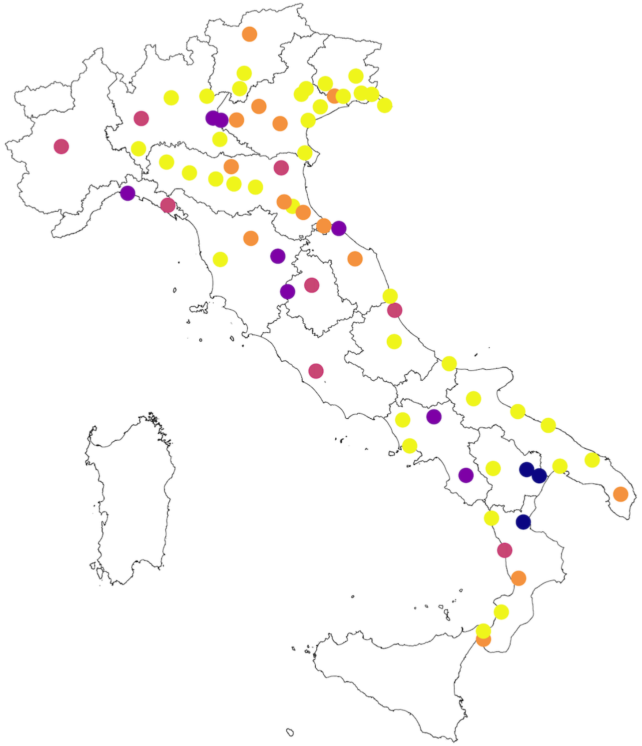
Accessibility change is due to access/egress time inclusion; the previous study considered only time components due to HSR services.

→ The indicator weights accessibility changes by time thresholds and by absolute (60%) and relative (40%) measures, and it is normalised with min-max.

- An **overall indicator** across all scenarios is derived as the arithmetic mean of the four indicators.

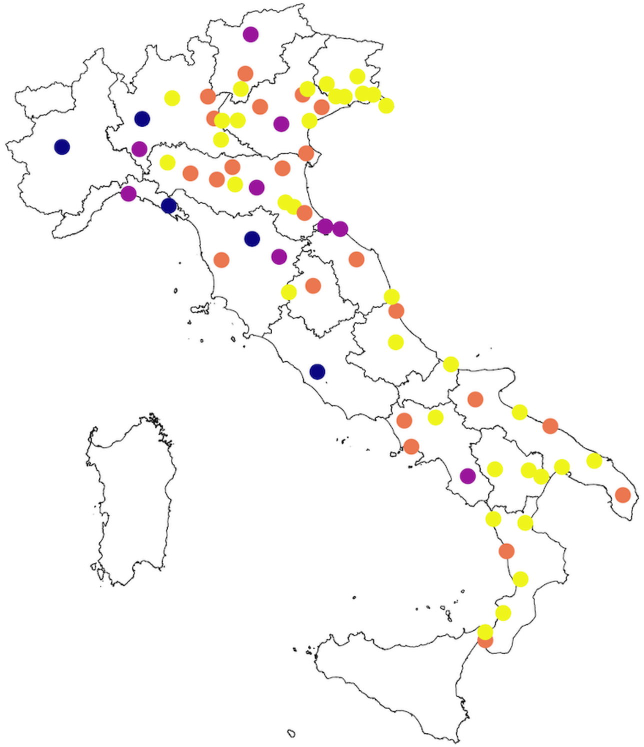
Results and discussion

Classification of the cities for the interpretation of the results



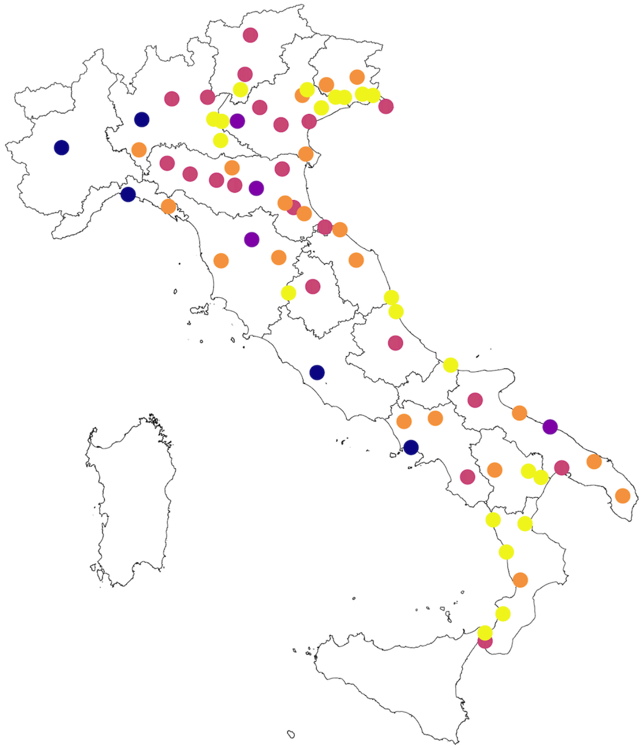
Centroid-station distance
(measured in km)

- ● VERY LOW (0–1.99)
- ● LOW (2–3.99)
- ● MEDIUM (4–5.99)
- ● HIGH (6–10.99)
- ● VERY HIGH (11–20)



Congestion level
(time difference peak vs non-peak hours in minutes)

- ● LOW (0.39–0.00)
- ● MEDIUM (1.49–0.40)
- ● MEDIUM-HIGH (2.49–1.50)
- ● HIGH (4.50–2.50)



City size (population in k)

- ● SMALL (<50,000)
- ● MEDIUM–SMALL (50,000–99,000)
- ● MEDIUM (100,000–249,999)
- ● MEDIUM–BIG (250,000–500,000)
- ● BIG (>500,000)

Results and discussion

Identified trends

1.

Structurally penalised large cities

(e.g. Rome, Milan, Turin)

Suffer the most due to both high congestion and high initial accessibility.

2.

Resilient small cities

(e.g. Monfalcone, Pisa, Lecce)

Low congestion and short station-centroid distances preserve accessibility.

3.

Cities with peripheral station

(e.g. Metaponto, Sibari, Chiusi)

Heavily penalised despite low congestion, especially in active modes.

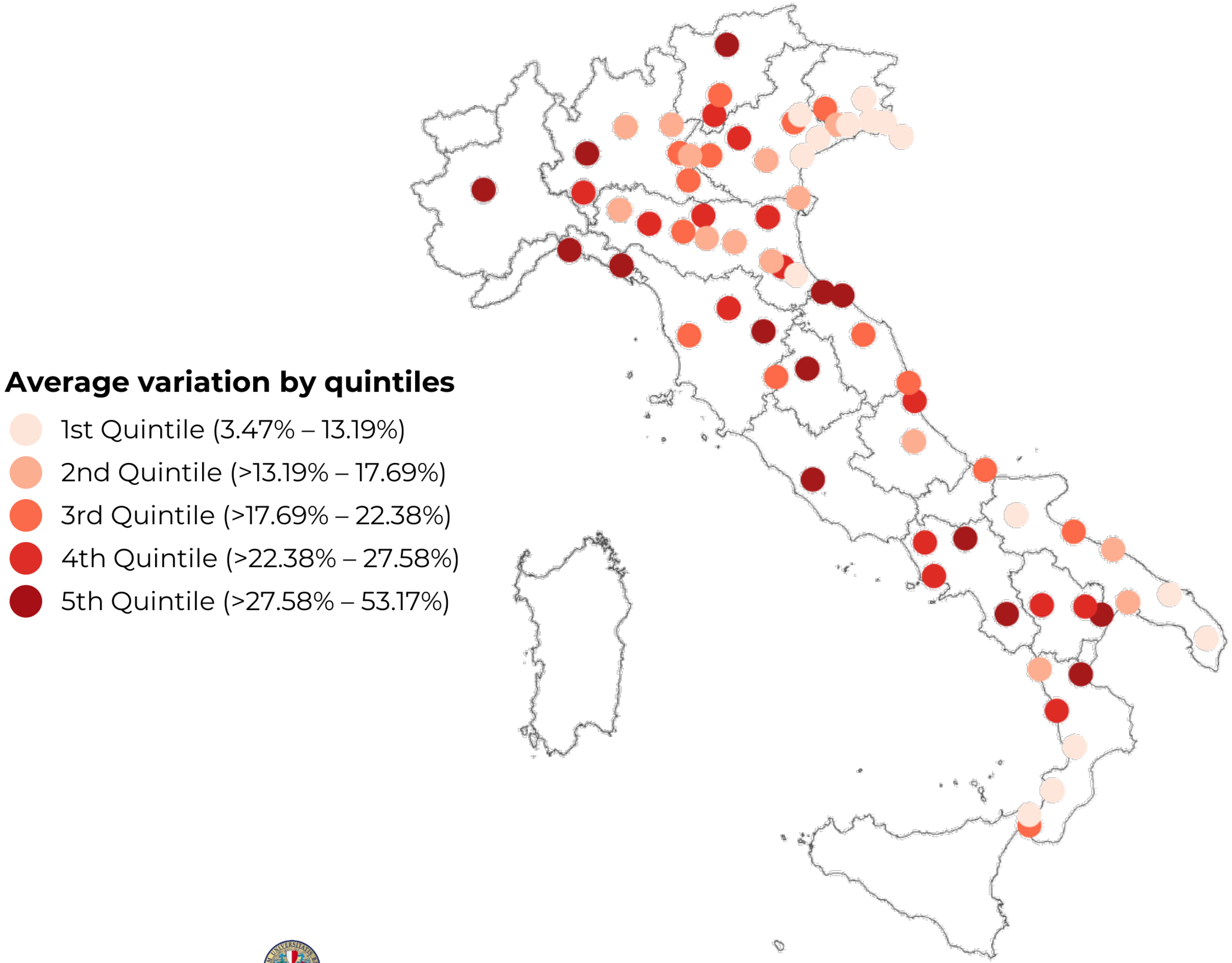
Average change in accessibility approximately **–22%**, but wide variation:

→ up to 50-53% in cities with long centroid–station distances or congested local road network

→ around 3-5% in compact and uncongested cities

Results and discussion

Accessibility change compared to the scenario without first and last mile times



Accessibility change is due to access/egress time inclusion; the previous study considered only time components due to HSR services.

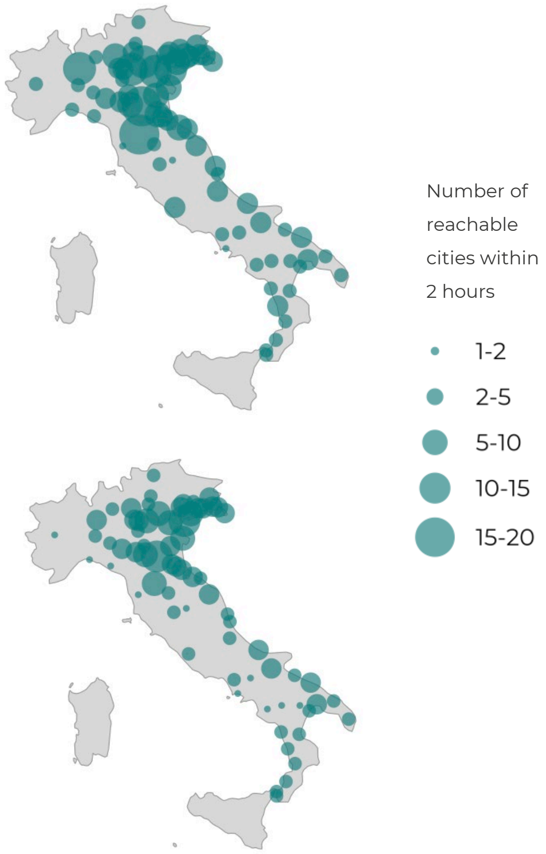
Results and discussion

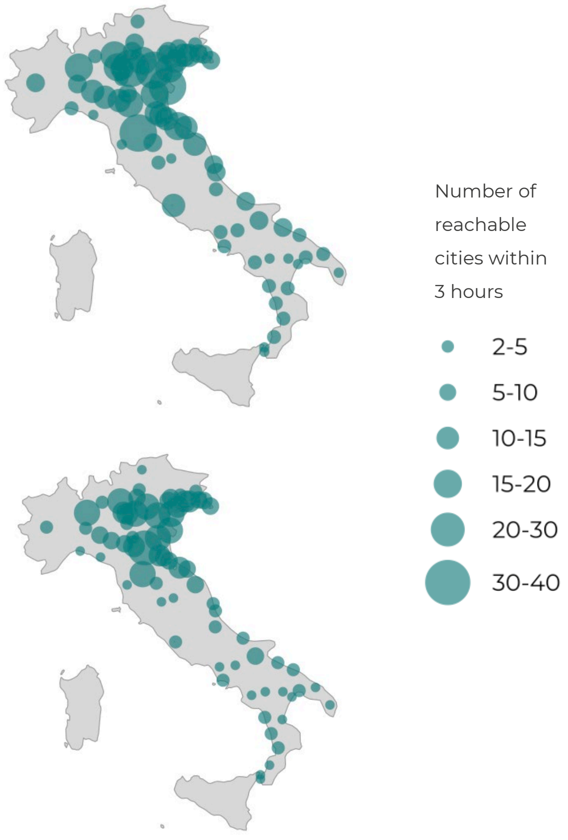
Reachable cities within 2, 3 and 4 hours

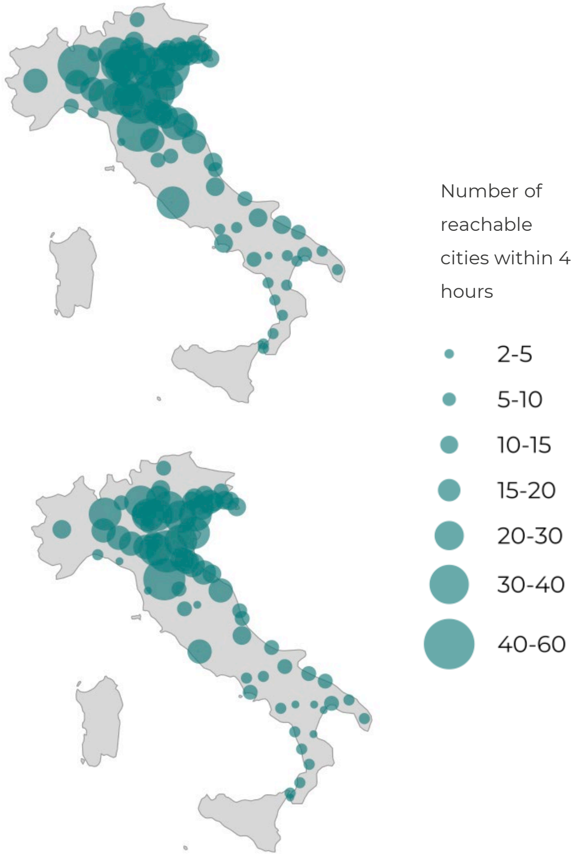
2 hours | **3 hours** | **4 hours**

without access/egress

with access/egress







Results and discussion

Results according to transport modes

Car:

- → highest variation in congested cities (e.g. Bologna and Arezzo);
- → congestion can lead to preference for non-motorised modes (e.g. Rimini and Genoa).

Walking/cycling:

- → most penalising for cities with long centroid–station distances (e.g. Metaponto, 50 positions less!)
- → in cities where the centroid–station distance is minimal walking and cycling outperform motorised options (e.g. Bari, Bergamo, Mantua, Cesena)

Final summary

- Neglecting access and egress leads to a **distortion of real connectivity**: the average change in reachable destinations reaches –22% once the urban segments are included.
- **Urban structure and station location matters!**
  Uniform assessments are misleading: change ranges from –53% to –3%, depending on local conditions (congestions levels, position of the station, etc.)
- **Improving urban connectivity helps ensure the effectiveness of HSR.**

  Being served by HSR does not guarantee by itself an enhancement of accessibility: if stations lack efficient local connections (walking, cycling, drivable routes) the impact of HSR may be reduced.
- Further developments could entail the integration of urban public transport networks to complete the picture of door-to-door accessibility.

Gruppo FS

The Mobility Leader

Thanks for your attention

#FSResearchCentre

https://www.fsitaliane.it/content/fsitaliane/en/fs-research-centre.html