High-Speed Rail as a Catalyst for High-quality urban development: Lessons from Case Studies

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Do High-Speed Rail Stations Accelerate Urban Growth? Insights from Italian Case Studies

Intro

High-speed infrastructure is a **key** driver of Italy's **economic growth**. It **connects** distant regions, makes the country more **accessible**, and **shortens** travel times.

High-speed railway stations are more than just transportation hubs—they are **gateways** to cities and play a **vital** role in **linking** territories, **creating** opportunities for people, businesses, and the country as a whole.

Objective of the study

This **study** aims to empirically analyze the **relationship** between **high-speed railway** (HSR) **stations** and **urban development** dynamics over **time**.

We adopted a **spatial-temporal analytical approach**, assessing changes in **multi-dimensional** indicator that reflect urban fabric.

In particular, an **ex-post analysis** was carried out on **two** of the most recent Italian high-speed rail stations: **Reggio Emilia AV Mediopadana** and **Rho Fiera**.

Introduction to the two Case Studies: where the station are located

Rho Fiera Station:
a connector to City, Fair, and Region

Reggio Emilia AV Mediopadana Station:
A New Gateway for the Emilia-Romagna Region

Introduction to the Two Case Studies

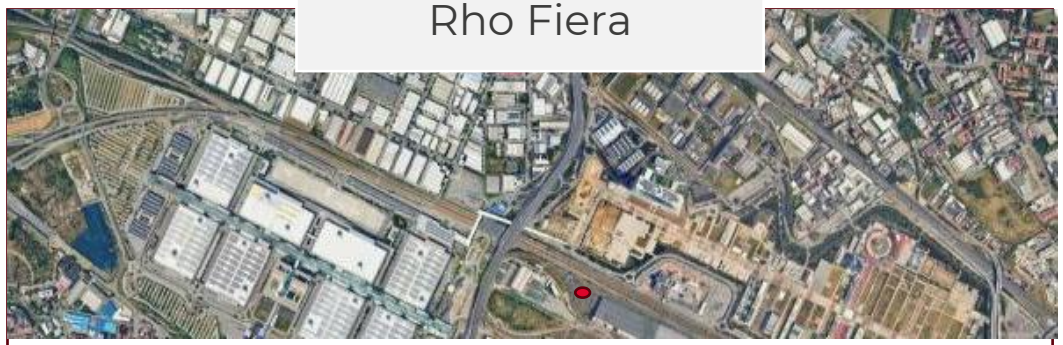
Mediopadana AV

Designed by the architect Santiago Calatrava, the Mediopadana high-speed railway station opened in **2013** as **the only intermediate stop** on the Milan–Bologna high-speed line. Located in an **agricultural area** close to the A1 motorway and 4 km from the city centre, it was conceived as a **new intermodal hub**.
It serves a large catchment area (Reggio Emilia, Parma and Modena) **relieving** traffic at the central stations.
The station forms part of a **broader urban and territorial redevelopment project**.
It has a dual role:

Reconnecting the territory by connecting previously divided areas and creating a new axis of development.

Urban catalyst: driving new growth and acting as a strategic gateway for the region.

Rho Fiera



Opened in 2008 Rho Fiera was designed as a major intermodal hub in a **densely urbanized** and commercial area, serving the Milan metropolitan region and the Expo district.

It connects the high-speed rail network with regional trains, metro lines, and local transport, ensuring seamless access to the fairgrounds and surrounding neighborhoods.
The station plays a dual role:

Supporting mobility: Facilitating easy access to Milan, the fairgrounds, and the wider metropolitan area.

Urban integration: Acting as a strategic gateway that enhances connectivity and stimulates economic and commercial activity.

Methodological Framework: a Spatio-Temporal analysis

The Spatio-Temporal analysis is based on **georeferenced** database that integrates demographic, economic, and land use variables. This database considers **multiple time points**, enabling the assessment of **urban evolution over time**.
The following is an overview of the steps undertaken in this project.

1. Hexagon grid: In order to perform a spatial-temporal analysis, we **normalized** the study area using a **hexagonal grid** (source: Uber H3), each hexagon measures 1km^2 ish. **This grid allowed for comparisons both over time and among spaces**

2. Database: For each hexagon we **point** each data sources (**Census population data** (2001,2011, 2021), **Industries** census data (2001,2011) and **registro imprese** data (2022), **Historical Open street map** (2006-2024) and **Corine land Cover** (2006,2012, 2018))

3. Urban development index: An **urban development index** was constructed for each case study, starting from the overall database. The variables were selected and weighted using **Sparse Principal Component Analysis** (SPCA)

4. Impact analysis: **Three isochrones** representing 15 minutes on foot, 15 minutes by bicycle, and 30 minutes by bicycle were constructed in order to **assess the impact of the station** in increasingly distant areas

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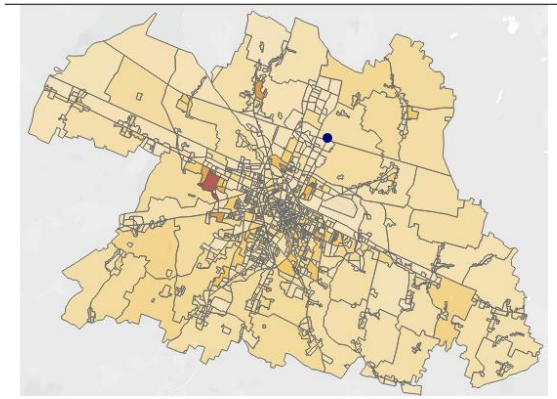
Methodological insights: the projection of census data onto a hexagonal grid using the CORINE land cover level

Census data were redistributed onto a **hexagonal grid** using the **AW+EM** (Areal Weighting + Enhanced Method) method, weighted by **CORINE Land Cover** to account for **differences in land use**.

Example: Preprocessing of population from ISTAT 2011

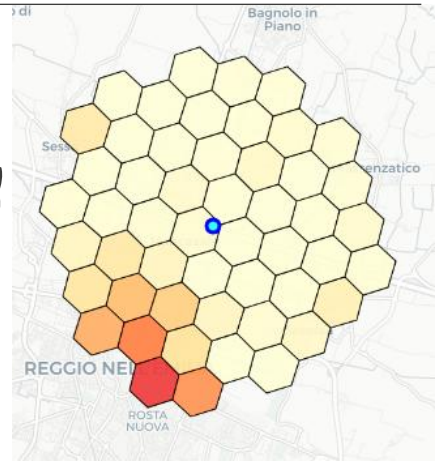


2011 ISTAT population mapped at the census cell level

AW+EM

Land use data from Corine Land Cover 2012

Uber H3 hexagonal grid



Population redistributed on a hexagonal grid using land-use-weighted asymmetric interpolation (AW+EM method)

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Methodological framework: a review of the key steps

Database

The database combines **spatial** and **temporal** infos.
The database uses a **fixed** hexagonal grid
Data includes services, population, employment, and land use.

Ex:
Y: 2001
Pop:1500
Hospital:1
Green area: 20%

Each hexagon is recorded for **three** years (**2001, 2011, 2021**) and classified **by distance** from the station (**15-min walk, 15/30-min bike**)

Urban Development Index

The Urban Development Index was built with a **bottom-up approach**:

- **Correlation** analysis and standardization of all simple variables
- **Sparse PCA** to extract 3–4 components of urbanization
- **Weighted components** combined into sub-indices and a single index

Station indices were built with **tailored** variables to **reflect** their **specific** urban context.
The index captures **data evolution** across 2001, 2011, and 2021

Impact analysis

Definited three isochrones (15 min walking, 15 / 30 min cycling), we compared average index values using a Difference-in-Differences (DiD) approach.

•**Treatment groups:** 15 min walking and 15 min cycling
•**Control group:** 30 min cycling (used only as a reference, acknowledging possible station influence)

Additionally, we compared hexagons with similar pre-station growth trends or matching baseline conditions, ensuring a more accurate assessment of the **station effect** on comparable areas.

Sparce Principal Component Analysis: key results

Mediopadana AV

For the first case study, the first 3 principal components were considered, they capture the highest variance and define three indicators:

- **Basic Services and Demographic Index** where the most important variables are population, num. of families, residential units, discontinuous urban fabric, cycleway, supermarkets, schools and residential road
- **Retail Services and Points of Interest** where the most important variables are continuous urban fabric, commercial units and cultural facilities
- **Transport and Industrial Infrastructures** where the most important variables are industrial services area, road and rail networks and associated land, secondary road, employees and residential road

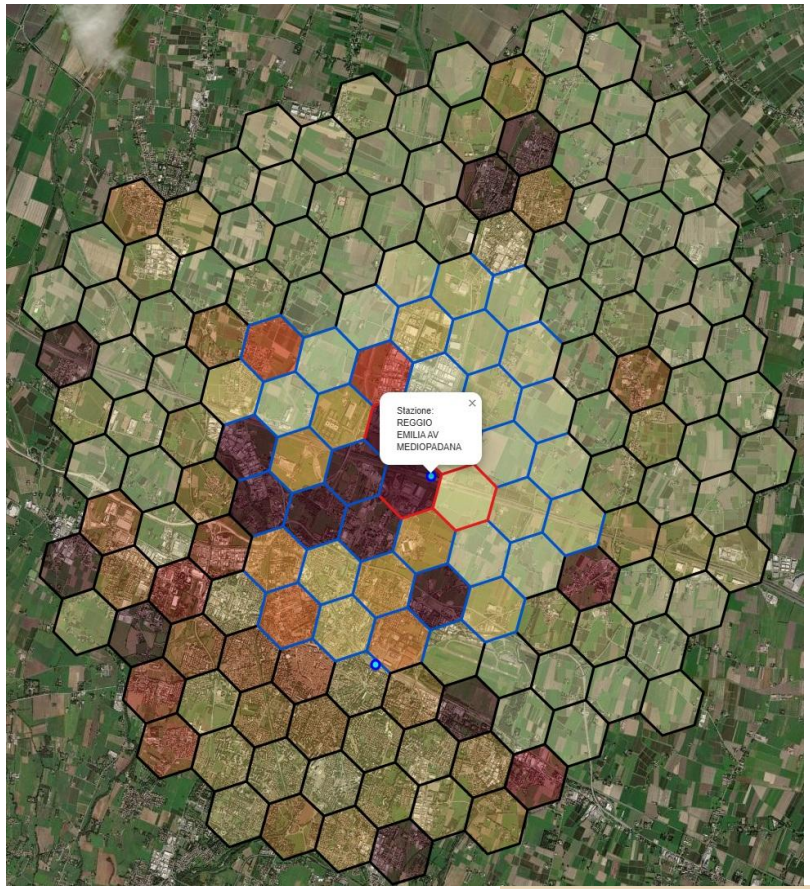
Rho Fiera

For the second case study, the first 4 principal components were considered, they capture the highest variance and defined four indicators:

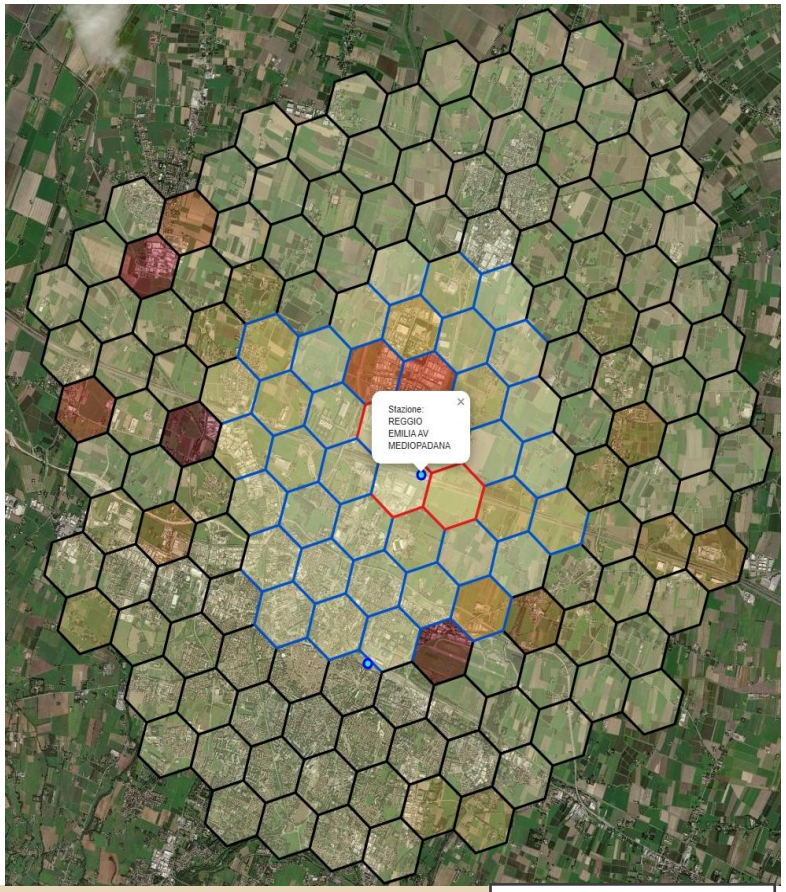
- **Demographic Index** where the most important variables are population, num. of families, residential units, discontinuous urban fabric, schools, and residential road
- **Transport Infrastructures** where the most important variables are motorway road, road and rail networks and associated land, secondary road, cycleway and residential road
- **Accessibility and Basic Services** where the most important variables are living street, cycleway, schools, pharmacies and continuous urban fabric
- **Retail Services and Points of Interest** where the most important variables are continuous urban fabric, commercial units and cultural facilities

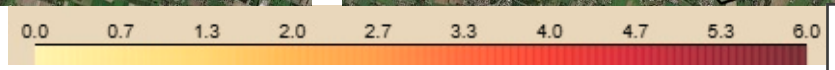
Reggio Emilia AV Mediopadana: Results and Findings

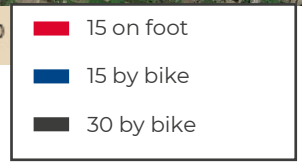
2011vs2001



2021vs2011







The data show that Mediopadana acted as a **catalyst** for urbanization.

Built in a predominantly agricultural area, the station sparked **new urban development** and became the starting point for a new attraction hub.

Data show that the area was already experiencing growth before the station was built, and the station reinforced this process.

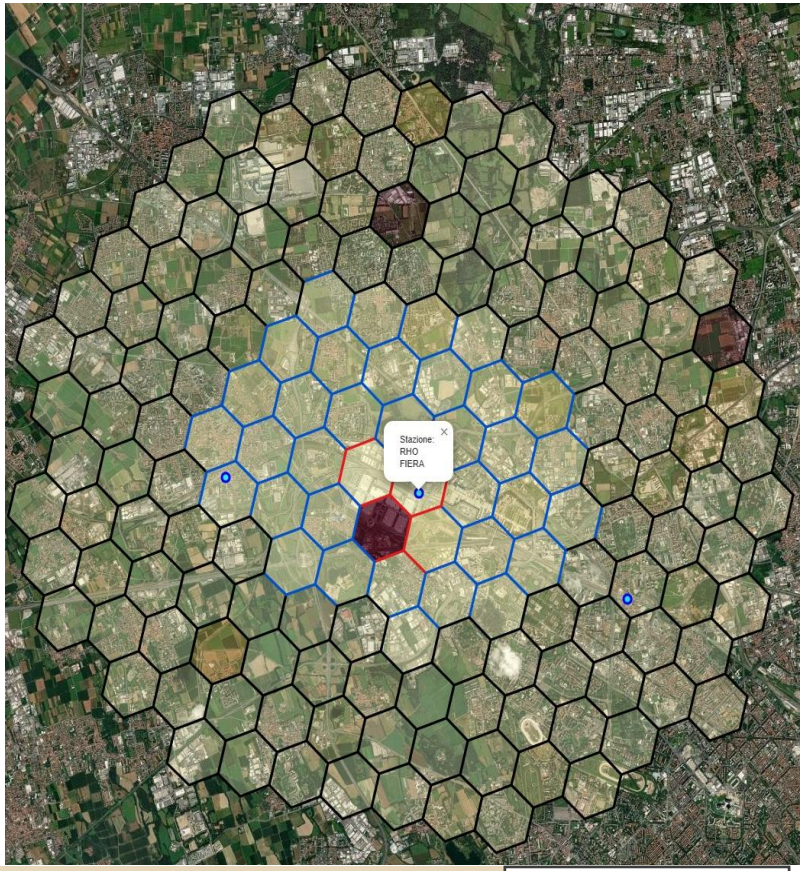
Comparing **DID** values within 15-minute walking and cycling ranges to the 30-minute by bike range, **increases** of **4.5% and 1.2% are** observed respectively.

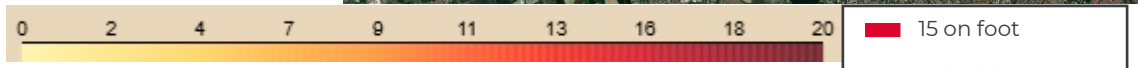
This growth aligns with the current setting, as the station is still located in a predominantly rural area.

Rho Fiera: Results and Findings

2011vs2001

2021vs2011





- 15 on foot
- 15 by bike
- 30 by bike

The station was integrated into a **highly dynamic** urban context, centered around the established economic hub of Fiera di Milano. Its purpose was not to generate new development, but to **connect** and **enhance** an already active and growing area.

Urban development around the station is not particularly pronounced.

The station seems to have a **greater impact** on the **15-minute cycling isochrone** (+14% did result against 30min cycling), likely due to **the improved connectivity** it provides with other point of interest in the area.

Methodological framework: a review of the key steps

This work constitutes a preliminary study into the role of railway stations as central nodes in urban systems, and their impact on urban growth and development patterns. An ex-post analysis was conducted to trying describing the complex relationship between railway station and the development dynamics of urban areas.

Case studies results

The analysis conducted proved the initial intuition:
Rho Fiera acts as a **connector**, **integrating and strengthening** an already **developed** area, such as the Fiera di Milano and the former Expo site.
Mediopadana, in contrast, functions as a **catalyst**, sparking **new urban development** in a previously agricultural area.
Finally, Rho Fiera **reinforces** existing growth, while Mediopadana **initiates** development in the less urbanized side (east side).

Methodological results

A **spatiotemporal** analysis framework was developed, along with methods to map data onto a hexagonal grid, enabling both **spatial** and **temporal comparisons**.

This work provides a solid foundation for potential future developments and further studies.

Future directions

Future work will focus on expanding the **geospatial database** and the **available data sources to finetune the urban development index.**

At the same time it will begin to define a **predictive framework**, aiming to **develop a tool** that could **support** decision-makers in determining optimal station location.

Thanks for your attention

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