High-Speed Rail (HSR) and Economic Development: A Counterfactual and Spatial Analysis, evidence from Italy

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Abstract

The relationship between public transport investments and economic and territorial development has been a subject of discussion among researchers and policymakers for several years (Mikessel et al., 2015). However, it remains a widely debated and underexplored topic, particularly in light of continuous technological innovations that have transformed both the modes and capacities of transport systems (Acheampong et al., 2022).

While extensive literature has demonstrated that increasing transport infrastructure and investments in the transport sector can enhance productivity and stimulate regional growth (Istadt et al., 2012; Chen, 2019; Bergantino et al., 2025), the actual effects of these interventions remain complex and context dependent.

Among various transport initiatives, the deployment of High-Speed Rail (HSR) services in recent decades has arguably been the most significant innovation in intercity travel worldwide. HSR systems are designed to reduce travel times and improve regional accessibility, aligning with previous literature that suggests enhanced connectivity fosters regional development and boosts productive activities. However, the magnitude and direction of these anticipated effects remain contested (Chen & Vickerman, 2017). One key concern is that HSR may primarily benefit already prosperous and economically dynamic cities, potentially exacerbating regional inequalities by diverting economic activity away from smaller or less connected areas.

During the 2000s, Italy's High-Speed Rail (HSR) network expanded significantly with the launch of the first dedicated high-speed railway lines, including Florence-Rome, Rome-Naples, Milan-Bologna, and Turin-Milan. Initially, the rail infrastructure and services were exclusively managed by RFI (Rete Ferroviaria Italiana) through its state-owned subsidiary Trenitalia.

However, the liberalization of the transport sector in 2012 introduced competition with the arrival of Italo – Nuovo Trasporto Viaggiatori, leading to an increase in connections between key locations.

Between 2010 and 2020, HSR services extended beyond the main routes, reaching smaller destinations as well. As of the latest data, more than 30 of Italy's 107 provinces are served by HSR, with stations typically located in provincial capitals (RFI, 2022). Among these, the province of Venice is also part of the network, with high-speed trains stopping at Venezia Mestre station, a key transport hub connecting regional and national routes. The latest generation of HSR trains can operate on both high-speed lines—reaching speeds of over 300 km/h and serving multimodal stations mainly in regional capitals—and on conventional railway lines, where they travel at up to 200 km/h, providing access to intermediate and smaller cities with basic station infrastructure.

In this context, the objective of this study is twofold. First, we assess the impact of HSR on business performance using municipal-level data. Second, we analyze the spatial distribution of these effects to investigate the presence of a "siphoning effect" (Niu et al., 2020), which could disadvantage poorer or more remote municipalities located farther from HSR stations.

The data used in this analysis consists of a panel dataset covering 107 Italian provinces over a 12-year period (2010–2022). The dataset is built using information from OpenStreetMap at the provincial level, allowing for a geographically detailed representation of economic activities. The panel structure enables us to track economic trends over time while accounting for regional heterogeneity.

The main outcomes of interest are the value added by sector of economic activity and employment. As control variables, we use GDP per capita and population. The inclusion of these variables is crucial for capturing economic performance and labor market dynamics across different regions. By focusing on value added and employment, the study aims to analyze the economic structure and workforce distribution within provinces.

GDP per capita and population serve as essential controls to account for differences in economic development and demographic composition.

This approach ensures a robust analysis by leveraging a comprehensive dataset that spans multiple years and regions, providing consistency in data collection and methodology.

To address these research questions, we employ a counterfactual approach to estimate the causal impact of the introduction of high-speed rail (HSR) on firm performance in Italy. The presence or absence of the HSR network constitutes our treatment variable, which takes the value of 1 if a province is served by high-speed rail and 0 otherwise. This binary classification allows us to systematically assess the economic effects of HSR by distinguishing between treated and untreated areas.

Our empirical strategy consists of two main steps. First, we apply a Difference-in-Differences (DiD) methodology to identify the direct impact of HSR introduction. This approach compares economic outcomes in provinces before and after HSR implementation, using non-HSR provinces as a control group to account for time-invariant unobserved characteristics and common economic trends. By leveraging panel data covering 107 Italian provinces over the 2010–2022 period, we ensure robust identification of the causal effects.

Second, we extend the analysis with a Spatial Difference-in-Differences (Spatial DiD) approach to explore the spatial dimension of HSR effects. This method allows us to examine whether the benefits of high-speed rail extend beyond directly served areas, influencing neighboring municipalities through spillover effects. The spatial analysis helps determine whether HSR fosters broader regional economic development or exacerbates existing disparities by concentrating benefits in already well-connected urban centers while leaving peripheral areas behind.

Furthermore, we incorporate additional control variables, including GDP per capita and population, to account for regional economic differences and demographic factors that might influence firm performance. By integrating both traditional and spatial econometric techniques, this study aims to provide a comprehensive understanding of the economic consequences of high-speed rail expansion, offering insights into whether such infrastructure investments serve as an engine for widespread economic growth or reinforce regional inequalities.

Our findings will contribute to the broader policy debate on the effectiveness of large-scale transport infrastructure in fostering economic convergence, particularly in a context like Italy, where economic disparities between regions remain pronounced.