RESEARCH REPORT

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Lessons Learned from Abroad: Potential Influence of California High-Speed Rail on Economic Development, Land Use Patterns, and Future Growth of Cities

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16. Abstract

This study discusses the potential economic and development impacts that high-speed rail (HSR) may bring to California. The research reviews the reported impacts of HSR implementation in various countries, particularly in Europe, and case studies of selected HSR station-cities in France, Spain, and Italy. The analysis suggests that HSR could bring economic development to the state and stimulate population growth but might eventually lead to gentrification in certain locations. Not all station-cities experience the same impacts, and certain conditions may foster greater economic development. Station location and connectivity to downtown areas would be particularly important in influencing these impacts, while peripheral stations would be less able to attract land use development and relocation of activities. The availability of rail service to larger cities (and connections to other major markets) and the coordination with urban planning and policy are key to determining the development of areas around HSR stations. The study indicates that for HSR to bring about desired economic development, the planning and design of stations and services must be integrated with the vision and urban plans of each station-city.

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Executive Summary

Executive Summary

This report addresses the potential economic and development impacts that high-speed rail (HSR) may bring to California. It consists of two parts: 1) a systematic review of existing research on the impacts of high-speed rail after its implementation in various countries, with a focus on Europe; and 2) a comparative case study analysis of the economic impacts of HSR in selected station-cities in France, Spain and Italy. The case studies were selected with the help of an international advisory board for the project and with an eye towards identifying cities that bear some similarities with certain Phase 1 California station-cities, as requested by the California High Speed Rail Authority. The comparative case study analysis presents a detailed description of each station-city, its station development, and the impacts that may be associated with HSR service. Finally, the discussion section brings the findings together and highlights how they may be applicable to California.

As a whole, this study suggests that the impacts of HSR could range from bringing economic development, stimulating population growth, and spurring transformation of the built environment, possibly leading to gentrification in certain locations. However, previous experience from abroad shows how not all station-cities are likely to experience the same impacts, and certain conditions may foster greater economic development. Station location and connectivity to downtown areas can be particularly important in influencing these impacts, while peripheral stations in most cases have been less able to attract land use development and relocation of activities. The availability of rail service connecting a station-city to larger cities and major markets and the articulation of urban planning and policy are also key in determining the development of the areas around HSR stations.

This research indicates that HSR service can lead to profound transformation in cities, but HSR alone may not be enough to bring about the desired economic development for California's station-cities. To encourage positive economic impacts from HSR, the planning and design of California HSR stations and services (including feeder transportation service to access the stations) must be integrated with the vision and urban plans of each station-city.

Contents

Introduction

New transportation networks facilitate mobility and may also spur economic development. This has been the case with the introduction of railways and automobiles, and the construction of railway and highway networks in the late 19th and mid-20th century, respectively. Over the past decades, a new transportation technology, high-speed rail (HSR), has had a profound impact on urban-regional accessibility and intercity travel across many countries in Europe and East and Southeast Asia. The economic and spatial impacts of HSR have been varied and largely contingent on a variety of factors, including local planning and policy. The many decades of HSR operation in Europe and Japan, among other countries, shows that there are possible short- and long-term benefits, and side effects, that HSR systems could bring to station-cities and regions, but these depend on various local conditions.

As California is in the process of building its own HSR network, it is important to review the experience of established HSR networks abroad and understand the possible economic effects that HSR can bring to regional and local economies, and their prerequisites. While the impacts of California's plan on the direct creation of jobs in local markets (e.g., construction sector) and on the travel sector (e.g., forecasts for HSR travel demand) have been the object of extensive investigation, the possible indirect impacts—including on land values, tourism, firm location, and local and regional development—have not gathered, to date, enough attention.

This study fills this gap. It gleans lessons for the development of California HSR by undertaking a comprehensive literature review of the economic impacts of existing HSR systems and conducting case studies of HSR station-cities in Europe. The literature review helps us identify the prerequisites necessary for certain positive economic impacts for different types of station-cities. In this report, we examine the impacts of HSR on post-construction job growth, firm relocation, land values, residential and commercial development, tourism, and population growth. We also present case studies of European station-cities that have experienced certain economic benefits since the introduction of HSR service to understand how and why these benefits have occurred. We chose several different cities and received input for the case study selection from the California High-Speed Rail Authority (CAHSRA) and from an advisory panel established for this project composed of five international experts on HSR.

An important note should be made about the choice of the case studies selected in this study, which are all located in European countries. We selected, and discuss in this report, case studies from station-cities in continental Europe because the context of planning and transportation, the role of government agencies, the way HSR is deployed, and the market dynamics in the U.S.—while certainly unique in their characteristics and different from many foreign countries—tend to be more similar to their counterparts in Europe than in most Asian countries. For this reason, while the authors of this study recognize that additional lessons could also have been drawn from HSR experiences in Asia, we decided to reduce the complexity of the project by primarily focusing on what can be learned from the analysis of case studies of HSR city-stations in Europe.

Research Questions

Drawing from our literature review and case studies analyses, we address the following research questions:

1. To what extent have HSR systems in European countries contributed to creating permanent jobs (beyond short-term jobs, e.g., in the construction sector) by attracting new businesses and firms in station-cities? What have been the most important preconditions for job growth to take place?
2. To what extent have HSR systems in European countries affected local real estate markets, including impacts on land values, or rent in station districts? How has the impact on real estate markets varied by the type of station-city (first tier, second tier, exurban, etc.) and by station-district location (central vs. peripheral)?
3. To what extent have HSR systems increased residential and/or commercial development in station areas, and what type (market rate, affordable) did they affect? What have been the most important preconditions for residential and commercial development to take place?
4. To what extent have HSR systems increased other economic activities in station-cities, such as tourism or business firm location?
5. Have economic benefits from HSR systems accrued throughout HSR corridor segments (*regional effect*) or been largely concentrated in some station-cities but not others (*localized effect*)? Has the HSR system contributed to the economic diversity and success of both smaller cities and primary cities?
6. What have been the social equity implications of HSR-induced economic development in terms of new housing and new jobs? What were the impacts of the changes on housing markets?
7. Are there particular policies (at the municipal, regional, state, or federal levels) that can contribute to successful economic impacts from HSR service?
8. To what extent are the lessons learned from HSR systems abroad transferable to California? Which factors may limit the transferability of the lessons learned, and how can they lead to potentially different outcomes in the state?

This report is composed of five sections including this introduction. In the second section we present the methodologies used to gather information including the processes used to select the case studies. In the third section we discuss the findings of the literature review. In the fourth section we discuss the findings of the case studies providing comparative data for each case study and discussing our findings on the economic effects of HSR. In the fifth and concluding section we present reflections on the findings from this study and compile some lessons learned that are relevant for HSR in California.

Research Methods

For this study we followed two main methodologies: 1) a systematic literature review of articles on the impacts of HSR, and 2) a comparative case study analysis of different European station-cities and their experiences after building and implementing HSR service. We begin by presenting the methodology for the systematic literature review process, and then follow by discussing the methodology for the case study process.

Literature Review

With over 40 years of HSR service in Europe, there is a burgeoning literature on the transportation, economic, environmental, and spatial impacts of HSR. We undertook a systematic review of the academic literature in transportation planning, geography, public policy, and economics that focuses specifically on the economic impacts of high-speed rail. We used the following databases during the literature review: Google, Google Scholar, Science Direct, TRID, SAGE, ProQuest Dissertation, and looked for articles published between 2000 and 2021 in order to get the most recent articles focused on impacts. We used the following search terms: "Europe high speed rail," "high speed rail + Spain," "high speed rail + Italy," "high speed rail + Germany," "high speed rail + France," "high speed rail + Belgium," "high speed rail + Netherlands," and "high speed rail + UK." We were interested in identifying articles that were discussing one or more of the following HSR impacts on station-cities.

- *Economic Impacts* (e.g., jobs, firm relocation, real estate development, land value changes, housing development, gentrification, regional development)
- *Physical Impacts* (e.g., land use changes, station-area development, infrastructure development)
- *Social Impacts* (e.g., population growth or decline, socio-demographic changes)

As Table 1 shows, we identified many articles, but after a review of their titles and abstracts, we only retained the articles that discuss at least one of the aforementioned impacts of HSR. We also focused on articles that evaluated ex-post (after implementation) impacts rather than forecasted impacts. Thus, we reduced the literature to be reviewed to a total of 81 articles relevant for our purposes (Table 2). In addition to these 81 articles, we also reviewed more articles for our case studies that focused on the particular station-cities examined.

Table 1. Search results.

Database	Search Terms	EU	SPA	ITA	GER	FRA	BEL	NED	UK
Google	"Europe high speed rail"	10,600,000	24,800	25,800	269,000	102,000	15,300	44,000	336,000
Google Scholar	"high speed rail" + country		11,500	11,100	16,700	16,100	5,800	10,900	18,000
ScienceDirect	"high speed rail" + country		819	701	1,118	1,062	342	549	1,035
TRID	"high speed rail" + country		234	138	150	222	41	66	207
SAGE	"high speed rail" + country		180	159	250	245	78	136	279
ProQuest Dissertation	"high speed rail" + country		3	1	9	14	1	2	27

Note: EU = European Union; SPA = Spain; ITA = Italy; GER = Germany; FRA = France; BEL = Belgium; NED = Netherlands; UK = United Kingdom

Table 2. Articles reviewed from each country/region.

Country/ Region of interest	Articles reviewed
France	12
Germany	9
Italy	6
Spain	21
UK	5
Europe-wide	24
Other	4
Total	81

Case Studies

To empirically ground the findings of the literature review and extract relevant lessons for California, we also conducted a comparative case study analysis of European HSR station-cities to examine if they have realized economic benefits after the introduction of HSR. To select the case studies, we created a summary table of the main characteristics of the California station-cities considering their population size, city typology (large

metropolitan, small metropolitan, rural, etc.) and expected location of the HSR station (central or peripheral). After compiling this information, we consulted with CAHSRA representatives and also received input from our expert advisory board, composed of five scholars who were each an expert on HSR development in either France, Germany, Italy, Spain, or the UK.

CAHSRA representatives indicated that they were interested in learning about the potential economic benefits from HSR on secondary (smaller) cities on the HSR network, rather than first-tier cities. We therefore cast our attention on such cities, and ultimately chose to focus on the following case studies:

- Le Mans, Reims, Le Creusot, and Vendôme in France
- Zaragoza, Valladolid, and the Galicia Corridor in Spain
- Reggio Emilia in Italy

Table 3 indicates some characteristics of these cities. As can be seen in this table, the case studies cities differ in terms of population size (ranging from 15,856 residents in Vendôme, France, to 675,301 residents in Zaragoza, Spain), land area (ranging from seven sq. mi. in Le Creusot, France, to 376 sq. mi. in Zaragoza), and distance from major cities (ranging from 92 from Vendôme to Paris to 373 miles from Santiago de Compostella, on the Galicia Corridor, to Madrid). The population density of the station-cities ranges from a low of 1200 people per sq. mi. in the cities along the Galicia Corridor in Spain to 6,990 residents per sq. mi. in Reims, France.

Table 3. Characteristics of case-study cities.

City	Population	Area	Pop Density	Distance from major city	Station location in the city
Le Creusot, France	21,057	7 sq. mi.	1200/sq. mi.	170 mi. from Paris; 81 mi. from Lyon	Peripheral
Vendôme, France	15,856	9.2 sq. mi.	1700/sq. mi.	92 mi. from Paris	Peripheral
Le Mans, France	143,847	20.4 sq. mi.	6990/sq. mi.	130 mi. from Paris	Central
Reims, France	215,275	18.1 sq mi.	5230/sq. mi.	93 mi. from Paris	Two HSR stations; one central, one peripheral
Zaragoza, Spain	675,301	376 sq. mi.	1800/sq. mi.	204 mi. from Madrid 186 mi. from Barcelona	Central (1.6 miles from city center)
Valladolid, Spain	302,000	76 sq. mi.	3900/sq mi.	100 mi. from Madrid	Central
Santiago de Compostella (Galicia Corridor), Spain	97,858	80 sq. mi.	1200/sq. mi.	373 mi. from Madrid	Central
Ourense (Galicia Corridor), Spain	104,596	32.6 sq. mi.	?	311 mi. from Madrid	Central
Regio Emilia, Italy	169,545	89 sq. mi.	1900/sq. mi.	96 mi. from Milan	Peripheral

We compiled information from each case study on the type of economic benefits accrued in the labor market, commercial real estate and housing markets, station-area development, and tourism, and population size. We collected archival data on these topics but also queried our expert panel about economic outcomes associated with HSR in these cities, and their understanding of the important preconditions that were in place and may have enabled these impacts to occur. Through these archival and literature review data and expert queries, we discerned the role of various factors (e.g., city and station location, existing policies and plans, state of the economy, etc.) on the impacts and reflected on the potential lessons learned from each case study for the California station-cities.

Research Findings

Literature Review

With over 50 years of experience in Japan and 40 years in Europe, there is a burgeoning literature on the transportation, economic, environmental, and spatial impacts of HSR coming from transportation planning, geography, public policy, and economics. Several literature reviews have also been published on the impacts of HSR. For example, Givoni and co-authors have compiled studies examining four kinds of HSR impacts—transport related, spatial, socio-economic, and environmental (1). Bazin and co-authors have compared the academic and professional literature in order to understand the expectation gap (2). Loukaitou-Sideris and co-authors have examined both predictive (ex-ante) and observational (ex-post) studies about the impacts of HSR (3). Yin and co-authors, seeking to extract lessons for China's high speed rail system, have synthesized studies on the direct transportation impacts and indirect spatial development impacts of HSR at the regional, urban, and station-area levels (4). Chen and Vickerman have reviewed studies on the evolution of theory and practice on the wider economic impacts of HSR investments (5). Recently, Chen and co-authors have examined the literature seeking to distinguish the short- and long-term urban form and economic impacts of HSR at both the regional and city levels (6).

Variable Impacts of HSR Systems

A growing literature shows that HSR systems can bring certain economic benefits to local and regional economies, but not all station-cities benefit equally from the introduction of HSR service (7). An early study providing a review of HSR impacts in Japan, France, and Germany on population and employment growth, ridership, business behavior, real estate values and activity, employment, and residential location concluded that HSR effects are highly variable (8). Factors that may influence the economic performance and type of impacts stemming from HSR projects include the size of a station-city, its position in the regional hierarchy of cities, and distance from first-tier cities on the network (9), station location within a city, station connectivity and intermodality (10), level of HSR service (11), existing cultural or tourist assets and amenities that may receive a boost from the arrival of HSR (3), the condition of the local economy, as well as the type and extent of government planning and intervention (6) (8).

Another important variable is the timeframe of evaluation; scholars find that the economic impacts of different HSR projects may vary in the immediate, short, or long term (12). Indeed, scholars warn that seeking to isolate the role and impacts of HSR from other factors influencing a city's or a region's economic development is a major methodological challenge. This is true because it is difficult to observe and differentiate the impacts that come directly from the arrival of HSR service from those related to wider economic trends present in a city or region (13). Therefore, it is important to consider not only the short-term but also the long-term impacts and processes, the wider economic and social impacts, and also compare metrics of economic outcomes to those of similar non-HSR cities and regions (12).

Additionally, the literature indicates that the economic and development effects of HSR may be unevenly distributed among cities (14) (15). Most scholars seem to agree that HSR redistributes economic activity, moving it from locations bypassed by its services to locations made more accessible because of them (3).

Our literature review showed that the most documented HSR impacts are economic impacts, such as real estate development and job creation, followed by physical impacts, environmental impacts, (especially related to modal shifts and emission reductions from air and road travel). Only a few studies discuss social impacts, such as gentrification and population growth, and a few others mention changes in urban policy or planning regulations (e.g., zoning). Table 4 lists the different categories of possible HSR impacts, along with examples of studies referring to these impacts.

Table 4. Categories of possible impacts of HSR on station-cities.

Economic	Physical	Environmental	Social	Policy
Job growth (28) Firm attraction; firm relocation closer to the HSR (56) (32) Increased land values (28) (18) (31) Real estate development (28) Increase in tourism (46) (64) (44)	New commercial buildings/uses around station (28) (56) Attraction of residential and cultural buildings/uses around station (54) Greater integration between larger cities and their outlying dormitory towns (18) (26)	Modal shift from air and road to rail (65) (59) (11) Reduction of local emissions (11)	Population growth (25) (27) Workforce flows (25) (40) Gentrification (40)	Zoning changes, new plans to support mix of station-area uses (66) New urban policy articulation (61) (180)

One factor that the literature finds significant in influencing economic outcomes is city size. Studies in European (16) and Asian contexts (17) find that HSR in first-tier cities plays a different role and requires different preconditions in catalyzing economic development than in second-tier cities. In general, the literature points out that first-tier cities (those that are the largest and most highly developed in their countries) are the primary beneficiaries of HSR. However, other cities may also benefit by acquiring greater visibility in the minds of people who live in metropolises (18). Some of the benefits of HSR for second-tier cities relate to a revamped

and more "modern" image and increased visibility (19). For example, in France, the high speed *Train à Grande Vitesse* (TGV) has had catalytic effects in the growth and development of second-tier cities such as Lyon and Lille (20). In Germany, small cities along the Koln-Frankfurt HSR corridor saw substantial increases in their Gross Domestic Product (GDP) compared to other local towns (21). In Spain, small and intermediate-sized cities on the HSR network, less than one hour (up to 100 km) away from major metropolitan centers, accrued population growth, thanks to their integration to the larger metropolitan network, which also helped them attract new economic activities, housing investments (16) (22) (23), and population (16). Indeed, under certain circumstances (e.g., good station location and urban and transportation services), small cities on the HSR network that are less than 100 km away from a major metropolitan center, have shown that they have the potential to transform into metropolitan sub-centers (16) (22). Some scholars have also argued that HSR may extend the spatial reach and economic role of exurban "edge" cities, particularly where it is combined with airport facilities (24) (20).

On the other hand, a study examining the London–Paris–Brussels–Amsterdam cross-border service (referred to as the North-West Europe HSR system) within the Schengen Area, between 1989 and 2015, finds that HSR service alone is insufficient to bring economic development to smaller station-cities, particularly if the level of service at those stations is low. Thus, smaller cities along the HSR route in the Schengen Area have typically not witnessed significant HSR-induced economic benefits, as compared to the major cities the route connects. The author argues that poor levels of HSR service combined with the absence of supportive local planning to ensure complementary development around stations results in a lack of economic benefits for these smaller cities, located in intermediate areas between major metropolitan centers on the HSR network (11).

Population Growth

Does the arrival of HSR service contribute to population growth in station-cities? The answer depends on the context of a particular city. Some scholars have used case studies to examine this question.

Looking at Spain, one study compared the population growth of each HSR station-city with those of Spain overall, non-HSR municipalities, a random sample of non-HSR cities, and similar non-HSR cities between 1991 and 2001 (ten years) and between 1991 and 2016 (25 years) (25). It found that:

- HSR cities more often experienced positive population growth relative to that exhibited by similar non-HSR cities.
- HSR provided a clear benefit for very small, isolated cities.
- Population growth depended on the extent of each city's transportation changes, the time elapsed from the initiation of these changes, and the location and size of the city.
- Local economic dynamics and stakeholder behaviors were very important to the overall development of the city.

Using a household survey and looking specifically at Ciudad Real, a small city 50 minutes from Madrid on the HSR line, scholars found that HSR helped the city acquire a greater territorial role, by attracting intra-provincial

immigration and investment, as well as immigrants and investments from other provinces. The relative short ride on HSR to the Spanish capital allowed some workers to also start living in Ciudad Real and commuting to Madrid for work (18).

Indeed, some scholars have looked explicitly at the effect of HSR on worker mobility. One particular study examined the impact of the HSR network expansion in Germany between 1994-2010 and the subsequent reductions in commuting time between regions on the commuting decisions of workers and their choices regarding where to live and where to work. It found that the share of workers commuting across county borders rose from 27 percent in 1999 to 33 percent in 2010. This rise in commuter numbers was mainly the result of workers changing jobs from larger to smaller cities, which have become more easily accessible as a result of faster train connections (26). Thus, HSR may lead to an increase of residents in smaller cities as people may decide to live there and continue working at the larger centers. Additionally, the authors argued that benefits from HSR were greater in peripheral regions, which gained access to a large pool of qualified workers with a preference for urban life (26).

Another study examined the population and economic development impacts of the HSR development in southeast England from 1996 until the mid-2000s. In particular, this study examined Ashford, a medium-sized city served by the so-called HS1 rail service. It found an 11 percent increase in the city's population in the 1990s as compared to southeast England as a whole, a difference that was, however, not found to be statistically significant (27).

Jobs and Economic Growth

In general, scholars find that HSR-driven job growth has been the highest in central urban areas, and cities with HSR stations have fared better in terms of job growth. The labor market impacts of HSR tend to be point-specific, in spite of its corridor nature (28).

Some French studies examining the HSR effects on job concentration and relocation indicated that job decentralization from Paris did not take place because of the TGV in France; rather firms from other cities opened offices in Paris (29) (30). However, one study found that fewer than expected Lyon-based firms relocated to Paris after the Paris–Lyon line was built, and second-tier cities such as Lille and Le Creusot had more difficulty than expected in attracting firms (31). Another study focusing on Reims, a city 81 miles (40 minutes on HSR) from Paris, examined the extent to which HSR affected firm relocation. It did not find a significant arrival of external firms in Reims since the launch of HSR service, but HSR contributed to easier access between branch and main offices. Banking and insurance were the top industries in firm relocation. The authors argued that the image of HSR can be an important selling point for local economic development, but it may take some time (an adjustment period) before HSR service becomes an important factor in firm location (32).

While the relocation of firms may have not occurred to a significant extent in French second-tier cities, for many firms the impact of high-speed travel has been significant because easy, one-day round trips on the TGV have allowed them to expand their operating zone, enhance coordination among their different geographic

units, and even achieve economies of scale (33). Looking specifically at Lyon, one study found that its firms benefited greatly by the enhanced accessibility and greater exposure and linkage to Parisian markets through HSR (34).

Similarly focusing on French HSR (from 1982-2006) but also looking at some specific nuances, such as type of HSR service and type of jobs, one study found that urban areas served by full-service HSR have faced a lower rate of executive job creation, but HSR infrastructure has boosted local annual economic growth rate by one to three percent (once corrected for selection bias). By contrast, areas served by HSR operating on standard-speed track experienced better average economic performance, though the effect directly due to the rail infrastructure was negative (between -1.1 percent and -3.0 percent). The authors noted that it was difficult to distinguish the economic impact of HSR from those of broader economic trends (35).

Examining the economic impact of the German HSR track connecting Cologne and Frankfurt and of the construction of intermediate stations in the towns of Limburg and Montabaur, scholars observed positive economic development between 1998 and 2002; a one percent increase in market access led to a 0.27 percent increase in GDP. In the counties nearest to Montabaur and Limburg there was a five percent increase in economic growth that was not reversed in subsequent years. Thus, the greatest positive economic impact was in the counties nearest to the new Montabaur and Limburg stations. The increased accessibility and market access experienced by these two small HSR station-cities were key to promoting their economic development (21).

Focusing on the impact of HSR in Italy, since its inception in 2009 and until 2018, one study found that HSR has produced significant accessibility benefits for areas along its network and positive economic impacts across the country, though the greatest benefits accrued to regions where HSR service was introduced. More specifically, nationwide, a 2.6 percent increase in per capita GDP growth was observed over 10 years (0.3 percent annually) that was attributable to HSR. Areas with HSR service saw an average 5.6 percent increase in their GDP over the same period. Areas without HSR service also saw a 2.1 percent increase in their GDP, likely because these regions could still benefit from HSR through connections to traditional rail. On the other hand, HSR had some negative regional equity impacts in terms of travel time accessibility and cost for areas not served by HSR. At the regional level, the introduction of HSR in Italy led to an 11 percent reduction in equity in terms of travel time accessibility (comparing regions served by HSR to those not served) (36).

Examining the economic effect of the HSR on peripheral cities in Spain that have now become more accessible and better connected to larger centers, one study found an “obvious” but difficult to quantify effect on Seville: This city has become better connected to the “centers of decisions and production of the Spanish and European economy” (37).

In the United Kingdom, a study examining six routes of London-outbound trains serving major railway stations in 26 local municipalities, inquired about differential effects over 30 years both between HSR and non-HSR cities, and among each group of cities, to understand the effects of InterCity 125/225 rail service. There were differences among cities, based on whether they were located within one, two, or over-two-hours from London.

Towns within one hour from London via HSR had stronger economic performance than the national average; towns within two hours from London experienced population decline but less unemployment and higher gross value added (GVA); while towns beyond two hours from London via HSR saw no discernible effect. The authors concluded that HSR had "substantial and demonstrable effects" within the two-hour travel limit "thus helping to generate renewed economic growth." They noted, however, that HSR impacts have not been automatic or universal, but rather contingent on local conditions and demographic and economic trends. While their findings were limited, the authors also observed above-average tech and knowledge-intensive industry employment in HSR towns located within one or two hours from London (38). Another UK study, focusing on the effects of HSR on economically depressed South East England, found that because of major accessibility increases, employment growth in Ashford has outperformed its surrounding areas (26). Another study concentrating on the Ebbsfleet International HSR Station (located in the Kent region of East London, and one of the intermediate stations in the Channel Tunnel Rail HSR Link), noted its limited economic impact. While this station was supposed to boost regional economic development, this has not been the case. The authors attribute this to the limited number of daily HSR runs that stop at this station. They argue that at Ebbsfleet, as well as in other HSR-station cities that are largely bypassed by high-speed rail (i.e., where HSR only has a few daily stops), HSR cannot have catalytic impacts on economic growth and development (39).

In Spain, one study estimates HSR impacts on labor migration in three main Spanish interregional commuting corridors (Madrid-Toledo, Barcelona, Andalucía) using interregional labor mobility data from 2002 to 2014. It finds that HSR facilitates commuting between regions (in the 30 to 70-minute range) thus encouraging labor mobility; this is especially true for higher-income workers, if the rail operations are compatible with their work timetables. The higher the rents in large metropolitan areas (e.g., Madrid), combined with the presence of HSR service, help increase the number of commuter trips and, thus, the number of people living outside the city and commuting to work) (40).

In Japan, the HSR line, Shinkansen, had both local and regional economic development impacts on the country's employment growth patterns and resulted in increased land values around stations even in intermediate-size cities (41). The Tokyo–Osaka Shinkansen line has had a greater impact on the distribution of jobs than residents, and employers have mostly concentrated around the HSR stations in both Tokyo and Osaka (42). Cities with a Shinkansen station fared better in employment growth and had higher household income growth than those without a station (31), while employment growth in retail, industrial, construction, and wholesale sectors grew between 16 and 34 percent more in Japanese cities with HSR stations (28).

Regional Economic Impacts

Most studies examine HSR local effects on station-cities; very few studies have sought to extract and understand the regional economic impacts of HSR networks. One such study examined two regions, Manchester and its surrounding region in North West England and Lille and its surrounding region in Nord-Pas-de-Calais, France, to address a core question: Can the effects of HSR spread from the core city to surrounding region, or do they widen the gap between core and peripheral places? The authors found that in both regions, the arrival of HSR promoted the knowledge economy, but the specific aspects varied. The connection of the

two regions via HSR with London and Paris respectively strengthened the regional capital economically, but not some of the regions around it, especially former industrial regions. The comparison between the two regions indicated that the transformation of post-industrial regions and sub-regions towards the knowledge economy brought by HSR is a complex process involving more than simply being connected with high-speed trains; it is influenced by the economic trajectory of the area and its infrastructure needs at the time of HSR arrival; by the presence or not of a HSR hub strategy and the simultaneous improvement of the intra-regional transport network; and by the extent of the region's path dependency (for example being dependent on manufacturing) (43).

Tourism

Economic development can be instigated through tourism, and some scholars have examined the impacts of HSR on tourism. Following the opening of the Paris–Lyon line in France, summer tourism rose in Lyon, but overnight stays in the city fell because of its enhanced proximity to Paris, and the possibility of one-day round trips made available by the TGV services (28). At the same time, another study found that the opening of the TGV in 1983 strongly increased business travel (including travel for conferences, exhibitions, trade fairs, and corporate events) in Lyon (44).

The TGV expansion has allowed researchers to document tourism impacts on other French cities. The HSR line heading southwest from Paris (called *Ligne à Grande Vitesse Atlantique*, or LGV Atlantique and opened in two stages in 1989 and 1990) has significantly increased business travel in Le Mans and the number of Parisian visitors in Tours (45). The 2001 opening of the HSR link between Paris and Marseille (called LGV Méditerranée) did not lead to a noticeable effect on tourism, but, on the Marseille end, prompted increases in extended weekend trips, and in various categories of travelers (young adults and seniors) (45). An examination and comparison of the impact of OUIGO, a low-cost state-owned HSR service, to traditional full-service HSR (TGV) and to low-cost airlines found that low-cost HSR service helped attract a new class of price-sensitive customers and stimulate leisure trips that would not have otherwise taken place. Indeed, a quarter of OUIGO riders said they would not have traveled if the service had not existed (45).

A study that surveyed tourists in Paris and Madrid to compare the factors influencing a tourist's choice of a destination and the role of HSR in that choice found that the availability of HSR service provided a significant motivation for tourists to visit Paris, with 49 percent of tourists accessing the city via HSR. In contrast, the presence of HSR proved to be important for foreign tourists already visiting Madrid as a means of visiting other Spanish tourist spots (46).

Other than Madrid, scholars have also observed that in the Spanish cities of Zaragoza (along the Madrid–Barcelona line) and Cordoba (along the Madrid–Seville line), several businesses (including business meetings and consulting activities) and tourism have increased since the advent of HSR service (47).

In Italy, a study detailing the impact of HSR on tourism in 77 Italian municipalities between 2006 and 2013, found that those served by HSR attracted more Italian tourists, and tourists spent more nights at those destinations (48).

In Japan, a study found that "social-recreational" travel has prospered along the Tokyo–Osaka Shinkansen line, leading to an increase in hotel and restaurant businesses around stations (42). This is particularly evident in Kakagawa City, a midway station between Tokyo and Osaka, where a number of hotels, conference venues, and recreational facilities have opened to accommodate an increasing number of tourists (49).

Real Estate Development

Several studies have examined the real estate effects of HSR, finding a mixture of outcomes ranging from significantly increased development around HSR station areas to minimal or no development. Examining HSR station-areas around six mid-size European cities (Strasbourg, Arnhem, Stratford, Cuenca, Kassel, and Liege), a study found that different intervention strategies followed by their municipal governments (e.g., connecting the station to other modes, mitigating the station's barrier effect, consolidating a station's urban image) have led to urban regeneration around their HSR station-areas (50). Similarly, Lleida, another mid-size city in Spain utilized its historic railway station to accommodate HSR service, which stimulated development in the station's vicinity (51).

In contrast, in some other cities, scholars have observed that building an HSR station has not brought about any catalytic effects and has not been accompanied by significant development. For example, of the three new stations built along the Paris–Lyon line, only Lyon Part-Dieu has had a significant effect on station development, likely because many more trains stop there than in the Le Creusot and Mâcon stations (28). Berlin did not witness any significant impact from its HSR Hauptbahnhoff station on the real estate market of the station-neighborhood or the city (52) (53). The HSR station in Tours did little to regenerate the surrounding area; the Ashford station at Kent, UK, has experienced little development; and the Ebbsfleet International HSR station, 10 miles outside London, has so far only witnessed the building of a park-and-ride facility (3).

The literature shows that different HSR-city contexts may encourage the concentration of different types of land uses around HSR stations. Thus, residential uses have flourished in several locations. For example, an early report that reviewed development around HSR stations in different countries to identify policy implications for the California HSR listed multi-family housing as a prominent land use with opportunities for development in areas adjacent to many HSR stations (34). Another study focusing on France and Japan, found evidence that residential location choices take into account the presence of HSR. This was apparent in Vendôme, France, where the construction of HSR was associated with a significant reduction in travel time to Paris (now only 40 minutes away) and a large influx of Parisian workers (31). A study of Ciudad Real in Spain found that the city was able to attract to the station area a range of uses that require cheap land, including multi-family housing. At the same time, the authors found that demand for housing around the station depended on whether potential consumers were locals or immigrants, renters, or owners (18).

A range of commercial uses may also be attracted to the area adjacent to an HSR station. A 1997 study of the real estate impacts of the German InterCity Express (ICE) high-speed rail system found that demand for commercial space around the Kassel station on the Hannover–Wurzburg line increased by 20 percent, but also noted that data were limited because the line was new at the time of the study (28). Examining station-area

development in Germany and France, a later study found a proliferation of commercial uses in HSR station districts of first-tier cities, with residential and cultural uses as secondary (54). In Lille, station development has included convention, entertainment, hotel, and office spaces, which have transformed the central city district (55). The area around Lyon's Part-Dieu station has witnessed an increase in land values and a rising demand for office space (34). In the HSR-station area in Utrecht in the Netherlands, the city's largest shopping center, located at the station, was remodeled and expanded, while more commercial and office development was attracted to the station's vicinity (55). In Rotterdam, the city developed an ambitious station-area masterplan for its new HSR station that opened at the heart of the central district in 2014, which has attracted several high-profile real estate projects (55).

While the aforementioned studies examine the supply side of real estate investments, an equally important aspect to consider relates to the demand side, namely, the extent to which firms are attracted to locations near HSR stations. A stated choice survey of firms from 2003 in the Randstad region of the Netherlands (Amsterdam, Utrecht, Rotterdam, The Hague) found that HSR service made a station location more desirable for offices, and that the level of service was also an important factor in the desirability of HSR-adjacent offices. The study found that offices within walking distance of a station were valued the most; a positive "image effect" made offices near an HSR station more desirable because of their perceived status (56).

A more recent study focused on firms in Reims, France, a city which has seen its district near its central HSR-station transformed by new development. The authors surveyed firms in Reims in 2008, just one year after the initiation of HSR service, and also in 2014 (seven years later). They found that the image effect of HSR was helpful in attracting real estate investments in areas they had not considered before. The surveys showed the importance of local developers, local public stakeholders and of land availability, but also that HSR had become, for some firms, a direct location factor (57).

Focusing specifically on temporary office space that meets the growing demand for flexible ("nomad") workers, a study found that some of these spaces are accommodated at business centers that have been built at or near HSR stations in Italy and France. For example, such centers for services and business have developed at the HSR station-districts in Turin, Milan, Rome, Florence, and Bologna. Similarly in France, in addition to the EuraLille business center in Lille, the city of Les Mans saw the development of the new Novaxis business center near its HSR station, while more recently, business parks and business centers have been built around the HSR stations in Reims, Metz, and Strasbourg (58).

In general, scholars stress that the arrival of HSR service in a city is an important but not the sole component influencing station-area development. A study of HSR station-areas in mid-sized French cities found that the arrival of HSR in stations centrally located in a city has led to a variety of projects, while it has proved to be more difficult to foster development around peripheral locations. Station access by walking and bicycling is typically difficult in peripheral stations, and shuttle services that provide station access are often not well-utilized. On the other hand, some suburban stations in close proximity to central areas have witnessed new development. Additional important factors affecting development include the frequency and variety of HSR service and the quality of local connections (59). Additionally, a city's size and proximity to a large

metropolitan center may influence the extent and type of development. Thus, a study focusing on HSR stations up to one hour away on HSR from Madrid and Paris found different levels of developments in the HSR station-areas of these cities. The most significant (and in many cases the only significant) variable relating to development around HSR stations in these cities was population size (the greater the population size the greater the amount of development) (60).

In summary, the literature indicates that the launch of HSR service may serve as a boost for real estate development in the adjacent station area, but this needs to be facilitated by anticipatory planning (e.g., creation of a station-area masterplan) that considers which type of land uses are the most appropriate. Station-area development is also positively impacted by a central station location that is well connected to various destinations within a city, as well as frequent HSR trips that connect the city to major metropolitan centers. On the other hand, station-area development may not take place where there is a weak real estate market; lack of population and economic growth, presence of alternative development sites; and lack of intermodal connections to HSR station (61).

Land Values

The value of the land represents an indispensable part of real estate development, and a few studies have explored the impact of HSR on land values. The results have been mixed, which again indicates that specifics matter.

Some scholars have found a positive association between the arrival of HSR and increases in land values. For example, one study found a higher value growth in Japanese cities served by the Shinkansen rail service than cities without HSR (31). Focusing only on Le Mans, France, another study found that the opening of the TGV Atlantique line connecting this city to Paris coincided with a major increase (100 percent in three years) in the city's land values (28). Examining the impact of the initiation of HSR service on land values and housing values in Ciudad Real—a small city with a university in the Castilla La Manch region of Spain—another study found that the city saw an increase in both real estate development and land values because of the entry of the HSR station, which in combination with the presence of the university, also led to an increase in in-migration and population growth. More specifically, housing prices that had increased only slightly more (2.5 percent annually) in the city than in the whole Castilla La Mancha region before the HSR, increased 13.5 percent more after the launch of HSR services (18).

On the other hand, a study focusing on the city of Tainan, Taiwan, did not find HSR had a noticeable effect on station-adjacent property values. The authors attributed this to expensive HSR fares leading to only a small number of people using HSR for commuting purposes. They also argued that entrenched residential location patterns prevented a reshuffling of housing markets (62). Similarly, another study that developed a predictive model of land value changes near the newly developed HSR station in Berlin, Germany, predicted only a weak station impact on property prices (52).

Literature Review Conclusion

In conclusion, the literature on the observed economic impacts of HSR gives some clear implications even though the exact economic effects of HSR are difficult to isolate because of other trends and forces, which may occur contemporaneously with HSR capital investments.

In general, the reviewed literature shows that the HSR can bring economic effects to station-cities but alone cannot be an economic catalyst. It needs to be complemented by anticipatory planning and public capital investments, ensuring a good level of HSR service, and increasing the connectivity of the HSR system to other transportation modes.

Even so, a number of intervening factors can enhance or diminish the economic impacts of HSR systems on a city. These include city size and position on the HSR network (distance from metropolitan centers), frequency of HSR trains, station location and connectivity to other travel modes, conditions of the local land market and regional economy, as well as pre-existing city amenities and assets (e.g., tourist sites).

The regional economic impacts of HSR remain largely unexamined. The few studies that examine these impacts find that HSR systems seem to redistribute economic growth; in other words, cities in a region not served by HSR may witness adverse economic effects compared to HSR-station cities.

The literature also notes that, in addition to the short-term economic impacts (i.e., construction jobs, possible business disruption due to construction), one needs to also examine the medium- and long-term economic impacts to station-cities brought about by HSR systems (13) (63). Under positive circumstances, in the short and medium terms, HSR may bring about changes to commuting as well as to business and tourism travel that can boost a local economy. In the medium to long term, such trends may result in more significant firm and resident relocation (with firms moving to HSR-station cities and workers following the jobs), affecting local economic growth and the local real estate market and land values (13).

We believe that the above reviewed literature provides some lessons for California HSR, especially with regard to the need to encourage economic growth and development around HSR stations. The fact that the literature is not uniform in its assessment of the economic benefits of HSR on cities, further underlines that both context and policy matter.

Case Studies

Given the different impacts HSR deployment can have in various contexts, understanding how HSR has impacted some foreign station-cities can provide useful insights for the California station-cities. In this study, we examined the HSR impacts on four French cities, two Spanish cities and one regional HSR corridor segment in Spain, and one Italian city. This section presents the findings of these different case studies. When appropriate, tables organized by country provide a summary of the findings from the various case studies in that country.

France

France's HSR network (Figure 1) covers more than 1,677 miles. Its first corridor, inaugurated in 1981, connected Paris and Lyon. France has a varied selection of station-cities and corridors, several of which have some similarities with planned California HSR stations. In France, we examined the station-cities of Le Creusot, Le Mans, Vendôme, and Reims.

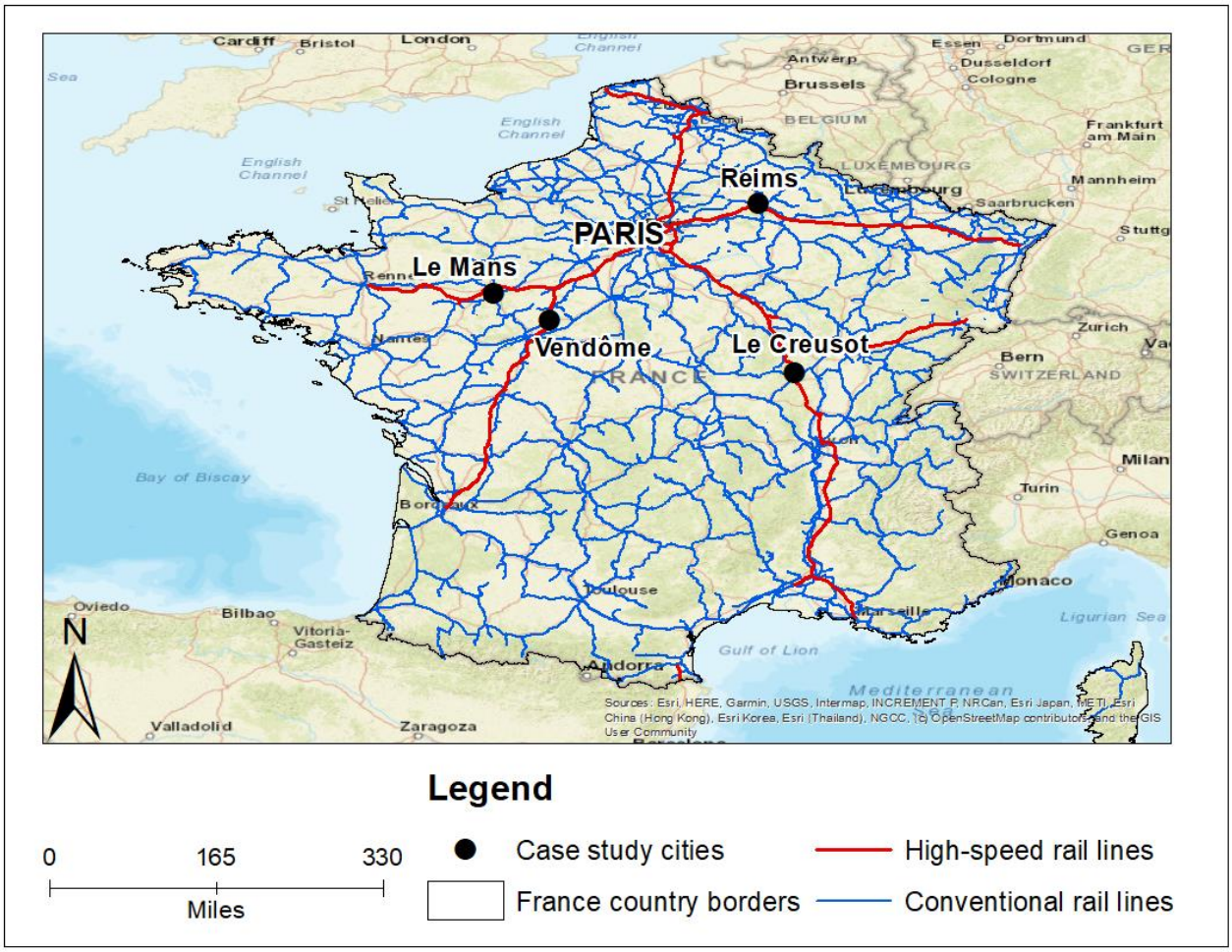

Figure 1. HSR network in France.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021), SNCF Réseau (2021).

Note: HSR lines in operation are represented in red; conventional lines in blue.

Le Creusot

City Description

Le Creusot is a small town surrounded by agricultural land in the Burgundy region of central eastern France. It is 170 miles from Paris and 81 miles from Lyon. The city has a strong industrial past, but its coal and steel industries collapsed in the 1970s (67), causing a progressive decrease in job opportunities and population, especially with the departure of young workers (68). Hence the population of Le Creusot fell from 32,149 to 21,269 residents in 1982, one year after the arrival of high-speed rail (68). Le Creusot's current population is fairly old, with 37 percent of its residents being retirees (68).

Le Creusot is part of the Communauté Urbaine du Creusot Montceau (CUCM), an administrative grouping of 34 small cities, which includes Le Creusot in the north and the neighboring town of Montceau les Mines in the south, with a total population of about 95,000 residents. Between 1982 and 2015, there was a 26 percent increase of service sector jobs in the CUCM, making the service sector, including market and non-market activities, the most important employer in the region (68) (69). For instance, in Le Creusot, approximately 33 percent of the jobs are in commerce, transportation, or other services, and 31 percent of jobs are in education, public administration, health and social services (68). This increase in service sector jobs reflects a larger trend at the national level (69). In reality, Le Creusot's service sector economy remains small compared to France's, whose service sector jobs represent 76.1 percent of the economy (68). Le Creusot is still called a "factory town" (69) and the economy in the CUCM is still focused on industrial activities: transport, energy and steel production altogether representing approximately 21 percent of its jobs (68).

High-Speed Rail Service and Stations

The French HSR network has prioritized connecting large metropolitan areas as quickly as possible, serving smaller cities in most cases through new peripheral stations instead of their historical central stations, which would have lengthened travel routes between larger cities (70). Le Creusot's HSR station is one of these stations, which was pursued by the local authorities of the adjacent small cities hoping to benefit from the new HSR service. These peripheral stations are nicknamed *gares du désert* (stations of the desert), or *gares-betterave* (beetroot stations) because of their isolated location on formerly rural land (71). The peripheral HSR station, named Gare TGV du Montchanin/Creusot/Montceau, is located on the Southeast HSR line between Paris and

Lyon. It is located in the periphery of multiple small and medium-sized rural towns, 8 km from Le Creusot and 26 km from Montceau-les-Mines, which gives the station a large catchment area (71) (Figure 2).

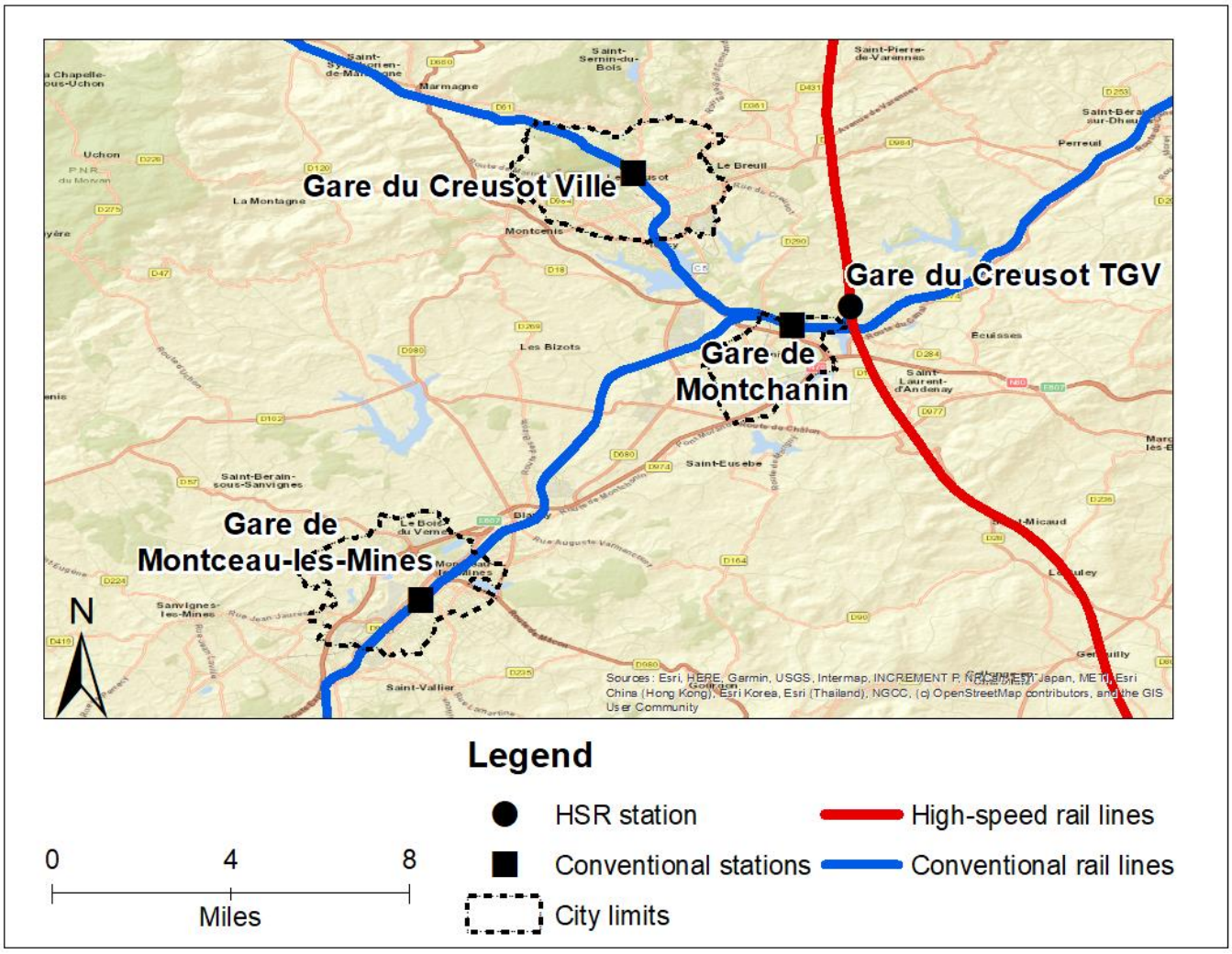

Figure 2. Railway stations in Le Creusot and its surroundings.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021), SNCF Réseau (2021)

Note: Le Creusot Montceau is a HSR station, while the other stations on the map are served by the regional network (TER).

Le Creusot's residents can reach Paris on HSR in one and a half hours, while it used to take them three hours forty minutes prior to the arrival of HSR service (71). At the same time, Lyon can be reached in 40 minutes. Out of the 22 daily round trips between Paris and Lyon operated by the French national railway company (SNCF), seven stop in Le Creusot. Since December 2021, high-speed trains operated by the Italian transit operator Trenitalia also started running between Paris and Lyon (72); however, these trains do not stop in Le Creusot (73).

The Paris-Lyon HSR stretch, inaugurated in 1981, was the first one operating in France. At the time, local authorities expected positive impacts for the territories served by high-speed rail. The initial 2.5 hectare business park planned next to the station was expected to solve the region's industrial crisis but it was never built (71). At the end of the 1980s, local policy makers attempted to make up for that deficiency by launching the Coriolis development project (Figure 3) (74). Covering a 50 hectares zone, this project was meant to attract firms and research activities but struggled to do so (71). To boost the site's weak attraction, in 2016 the CUCM started a large five million Euros development project in Coriolis (75). Currently, the Paris-Lyon line is being renovated and modernized with a 300 million Euros budget (76).

Figure 3. The Coriolis business park in 2012.

Source: Immo Hub 14 via La Fabrique de la Cité (77)

Impacts of HSR

The economic impacts of HSR service in Le Creusot were mostly below expectations. While the Coriolis project adjacent to Le Creusot's station was meant to attract new firms and jobs locally, the high-tech park only hosted 15 companies and two office buildings in 2009, more than two decades after its creation (78). Currently, there are still only 34 companies on site (79). Among the firms located in the business park, 30 percent cited proximity to the station as their main location factor in 2013, which shows that the station was a source of attraction for some firms (74). Half of these firms came from other regions, attracted by the city's new

proximity to Paris. The disappointingly low number of firms that the project was able to attract can partly be explained by firms opting for business parks with lower real estate costs (71) as well as the remoteness of the park and its lack of easy accessibility, which were a major drawback for firms (78). Additionally, public authorities were initially reluctant to invest in the business park because of fear it could undermine the success of other central business parks in Le Creusot (78). This changed in 2016 when the CUCM started the aforementioned large development project to make the site more attractive to companies (75). More recently, the CUCM voted that a focus during its new mandate would be to pursue this development project, investing in the creation of new office spaces for tertiary activities, and this construction has recently begun (80).

The lack of success of the business park in attracting new activities also stems from a disconnection between its ambition to become a high-tech park and the area's past strong industrial base, which was not in high-tech industries (74). Instead, there is a strong presence of freight transportation and wholesale businesses in the area. For instance, the activity taking up the most space on site since 2018 is Lidl's largest French logistics facility, Lidl being the leading discount retail chain in the country (81). This facility's presence contrasts with the initial expectation for Coriolis to accommodate high-tech activities (74). In Coriolis' current marketing material, authorities highlight that the site mostly welcomes industrial activities focused on innovation. This suggests that the authorities still hope to attract innovative firms, tertiary firms and more research activities instead of traditional local heavy industries.

When it comes to impacts on the job market, employment in the CUCM decreased by 22 percent between the arrival of high-speed rail in 1981 and 2015 (68). However, this does not relate to the HSR per se, but was mostly due to the industrial decline of the region during the same years. The small number of companies attracted to the Coriolis business park represented less than one percent of the jobs in the urban area (82). While high-speed rail service was expected to create local jobs, it also helped firms access external services, increasing their dependency on Paris in that regard (71). However, few people residing in the CUCM commute to work in neighboring large cities: just 300 individuals work in the Paris region and 200 in Lyon (68), and only a few companies have recruited managers from Paris and Lyon (74).

HSR service seems to have impacted business travel from Le Creusot. Employees of firms located in the business park travel on average two to four times a week (74), but this travel is not necessarily linked to the proximity to the HSR station. Twenty-seven percent of HSR users use the station very regularly, often to go to Paris once a week for business purposes (83).

The peripheral location of the station has been highly criticized for its lack of accessibility via public transport modes. The different shuttle options to reach the station from the surrounding cities have been blamed for their unreliability: they are not consistent, are canceled frequently, and the travel time to reach the station is long (78). Currently, the region is working towards a system which would allow passengers to buy a shuttle ticket between Autun and Le Creusot simultaneously with the high-speed rail ticket, making accessing the station easier through this intermodal connection (84). In this context of mostly unsatisfactory public transport options, those who use public transport to reach the station do it because they have no other travel options (83). Connecting the station with the conventional regional network via rail (TER) would have been beneficial

but very costly, which is why it was not done in the first place (71). However, this connection between the networks is still demanded, in particular by environmental activists (85). Due to the lack of public transport options to reach the station, 80 percent of the station's users reach it via private automobile (78).

Originally, parking near the station was free, which made accessing the station via car even more attractive (83). The lack of public transportation options to reach the station also fosters inequity; Le Creusot is hard to access for non-motorized households (78). High-income professionals such as managers and retirees are more likely to reach the station via private automobile, while students and low-income individuals depend on the very limited and unsatisfactory public transport options to reach the station (83). Moreover, the need for a car to reach the station was accommodated by building large parking lots next to the station, shaping the design of the station area (86).

Relevance for California

Initially, positive consequences were expected from the arrival of HSR service in Le Creusot. The failure of the initial development projects prior to the Coriolis project has shown that it is necessary for local authorities to collaborate and plan for the arrival of high-speed rail.

When translating the lessons learned from Le Creusot to Californiat, the peripheral location of this French HSR station in a small town in a largely rural area shows how important it is to prioritize station accessibility and connectivity. This might be also true for California HSR stations such as Kings/Tulare, Merced or Gilroy. Placing the station at a central city location and connecting it with other public transportation options would be beneficial for HSR users. It is also helpful to focus on making public transportation options for reaching the station reliable, frequent, and affordable, and to coordinate their service schedule with those of high-speed rail departures and arrivals. Le Creusot's experience has also shown it is important to focus on attracting firms that have a connection to the local ecosystem and economy. The failure of the Coriolis business park to attract many high-tech firms is likely due to the fact that such firms were largely unsuited to the industrial character of the region.

Vendôme

City Description

Vendôme is a small town located in central western France, in the Centre-Val de Loire region, 92 miles from Paris (Figure 4 and Figure 5). The city has a population of 15,856 residents (87). Vendôme has a rich medieval heritage and is located along the river Loir in a tourist region known for its vineyards and châteaux (castles). Almost one quarter (24.7%) of Vendôme's labor force works in the industrial sector, 32.6 percent in the service or transportation sectors, while 29.5 percent work in public administration, education, healthcare or social care work (87).

Since the arrival of the HSR in 1990, Vendôme's population has declined by approximately 9.5 percent (87). The local population is aging, as shown by the progressive decrease of students enrolling in the local kindergarten and elementary schools over the years (88). However, as discussed below, these population

trends may be reversing, thanks largely to the expansion of remote work during the pandemic, which along with the availability of a fast commute to Paris via HSR, has allowed new families to settle in the area.

Figure 4. Vendôme and surrounding region.

Source: SNCF

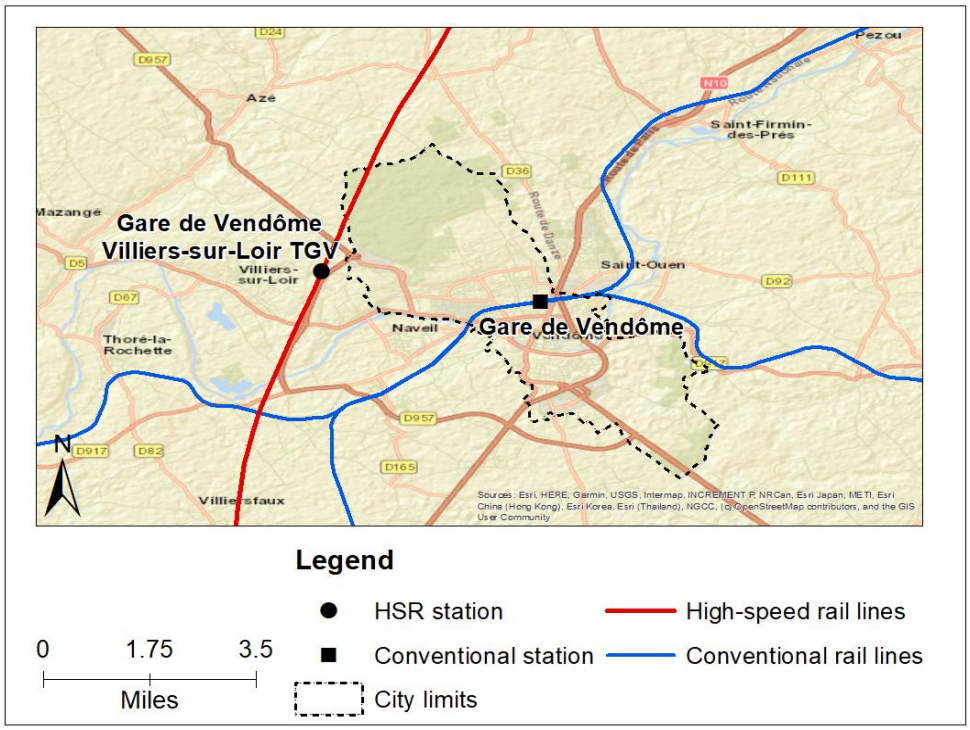

Figure 5. Vendôme and its HSR station.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021), SNCF Réseau (2021)

Note: HSR lines in operation are represented in red; conventional lines in blue.

High-Speed Rail Services and Station

Vendôme's HSR station, called Vendôme-Villiers-sur-Loir TGV, opened in 1990 (89). It is located in Vendôme's periphery, 2.5 miles from the city, next to a forest (86). Around the station, a 150 hectare technological park called *Le Bois de l'Oratoire*, referring to the adjacent woods, was developed in the 1990s to attract technological activities and firms (74).

Locating HSR stations in formerly vacant rural land was common at the time in France (70) (67), as it allowed authorities to compromise between connecting large metropolitan centers as quickly as possible, while also serving rural territories by HSR. Peripheral stations like Vendôme, however, are often given pejorative nicknames referring to their isolated and disconnected locations: they are sometimes called "beetroot stations" because they are built in rural land, or "stations of the desert," to indicate how isolated they are (70), or *gares bis* (bis meaning second), to suggest that they are only supplements to the cities' central historical stations (67).

Vendôme's authorities bargained with SNCF (the national railway company) to claim a station along the Atlantic HSR line and were able to obtain one by offering to finance the station and railway lines around it as well as provide land for the HSR infrastructure (67). Thus, thanks to the HSR, Vendôme is now only 42 minutes from Paris, while previously it took two hours 10 minutes to reach the capital by conventional rail (81). There are about 10 daily trips to Paris (90).

Impacts of HSR

While the population of Vendôme initially decreased by 9.5 percent after 1990, more recently the city has witnessed a wave of Parisian newcomers settling in Vendôme. After the first COVID-19 lockdown, according to multiple newspapers, there was an influx of individuals from the Paris region (91). According to the mayor of the adjacent town, Villiers-Sur-Loir, the primary school is about to open an additional class for the new children to be able to enroll locally (91).

Le Bois de l'Oratoire, the technological park built adjacent to the station, did not attract as many activities as expected: only 10 companies located there (86), and only 6.6 percent of the technological park is occupied (74). Le Bois de l'Oratoire was meant to attract high-tech companies, but it primarily hosts industrial and service jobs, and the largest employer on site is a call center (74). Those firms chose the location not primarily because of its proximity to HSR service, but because of the availability of suitable real estate and the positive local institutional climate (74). The failure to attract desirable companies stems from a disconnect between the goal to attract high-tech firms and the reality of the local context and economy. Initially, the site struggled to attract firms from other regions, as shown in Figure 6. However, more recently, between 50 and 70 percent of the firms locating in the Bois de l'Oratoire have come from other regions, which suggests that the technological park was eventually able to attract some outside activities. Moreover, some companies which would have likely left the area, stayed because of the climate of hope generated by the arrival of high-speed rail

(86). Recently, the firm Louis Vuitton was attracted to the Bois de l'Oratoire, bringing new hope for local economic dynamism (89).

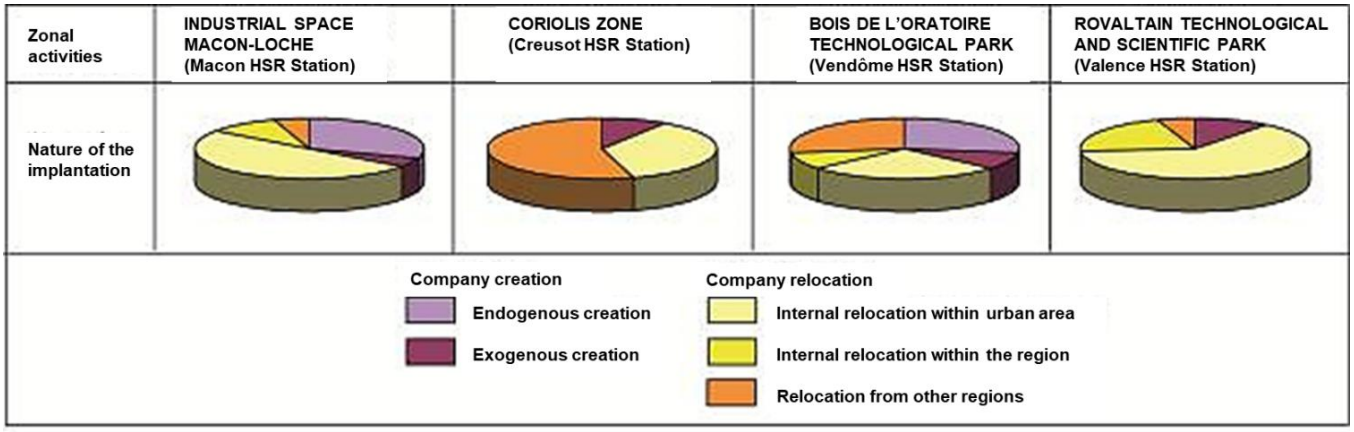

Figure 6. Origin of companies in business parks around peripheral high-speed rail stations in France.

Source: Adapted to English from Fachinetti-Mannone, 2010

Le Bois de l'Oratoire hosts three percent of the jobs of its urban area (74). While in 2000, 5,000 jobs were expected to be created in the Vendôme business park, by 2012, only 450 jobs had been generated (81). Before the arrival of HSR, there was an initial fear that Vendôme would become a dormitory town for workers in the Paris region. However, the high price of train tickets reduced this concern (86). Still, 35 percent of passengers travel back-and-forth to Paris for work (86), and according to some, Vendôme did become a dormitory for some Parisian workers (70). The concentration of food businesses around the station indicates that in late evenings, when commuters come back from working in the capital, local shops are crowded with customers (90), which again suggests that there are large numbers of commuters to Paris.

Because of the fear of creating a dormitory effect, housing was not added to the development project adjacent to the station. Despite this, several decades after the arrival of HSR, and largely because of the effect of the COVID-19 pandemic, real estate prices have increased in Vendôme. According to a local real estate agent, this increase amounted to about 10 to 20 percent in only one year. This same agent indicated that 60 percent of his clients come from the Paris region (92). Villiers-sur-Loire, located next to Vendôme, is comparable to Neuilly-Sur-Seine, a municipality next to Paris known for its wealthy residents and expensive real estate (91). This influx of Parisian families is partly due to new possibilities for remote work. The increased demand puts pressure on the available housing in the real estate market, and it has become harder for locals to afford properties in central Vendôme, and quite impossible to find a property for less than 170,000 Euros there, which was possible before (92).

In terms of tourism, Vendôme has so far failed to develop elements to attract tourists, as it had originally planned. For instance, the initial project to build a large tourist information center in the station was instead converted into a brasserie. Only a new artificial lake was eventually created to attract tourists (81).

Peripheral HSR service often scatters transportation hubs rather than concentrating different transportation modes in one area (70). In Vendôme, the station is poorly connected to public transport options and to regional trains (TER), making access to the city center complicated (70). As a result, parking space has to be added in order for individuals to access the station (70), which is environmentally problematic. Since the area surrounding Vendôme is "environmentally rich," because of the presence of a forest, the site was originally destined to host non-polluting activities (67); however, this was not realized. Lastly, the location of the HSR station next to a forested area, further isolates the station from other activities and destinations (81).

Relevance for California

The arrival of HSR provides regions with new economic opportunities but development strategies and the involvement of local authorities are critical in exploiting that potential. Availability of HSR service has proved to be useful to firms that have a connection to the local economy and labor skills, which suggests that development projects in California's small station-cities should plan on attracting industries and firms relevant to their local context.

Placing stations centrally or connecting them with regional networks is beneficial to territorial development and helps provide better HSR service (70). On the other hand, it is essential that HSR stations located in more peripheral areas are well connected to town centers through bus transit, vanpools, or other transportation modes. The lack of success of the adjacent technological park in Vendôme is likely related to the station's poor transportation connections to the city center.

Since the pandemic, the possibility for remote work has generated increased interest in rural areas served by HSR. As has recently occurred in Vendôme, former urban residents could likewise move to California's exurban station-cities, which are only 20-40 minutes from metropolitan centers (e.g., in the case of Palmdale or Gilroy); they could also work remotely and access metropolitan centers periodically for amenities and recreational services. The arrival of higher income residents from metropolitan areas, on the one hand, offers these residents housing options at a lower cost. On the other hand, it increases demand for local real estate and could raise land values and rents. As a result, locals might be priced out of the real estate market, unless policy makers and planners initiate inclusive zoning and other anti-displacement strategies.

Le Mans

City Description

Located in western France, in the Pays de la Loire Region along the Sarthe River, Le Mans is the capital of Sarthe County and is 130 miles from Paris by car (Figure 7). The city is known for its gastronomy but also for hosting the *24 Hours of Le Mans*, a well-known sports car race that dates back to 1923 (93).

In 2019, central Le Mans had 143,847 residents (94), while the metropolitan area population was 347,397 (94). The central city has a population density of 6,990 residents/sq. mi. while the metropolitan area has a density of just 447 residents/sq. mi (94). Originally known for its industrial base, starting in the 1990s Le Mans' economy progressively transitioned into the service sector (39). The insurance industry has been part of the

city since the 19th century with the 1828 creation of the Mutuelles du Mans Assurances, an insurance firm which currently employs more than 7,200 workers in France. The industrial sector has grown throughout the years and helped the city resist deindustrialization (95).

Figure 7. Le Mans location in relation to Paris and HSR lines.

Source: SNCF Réseau

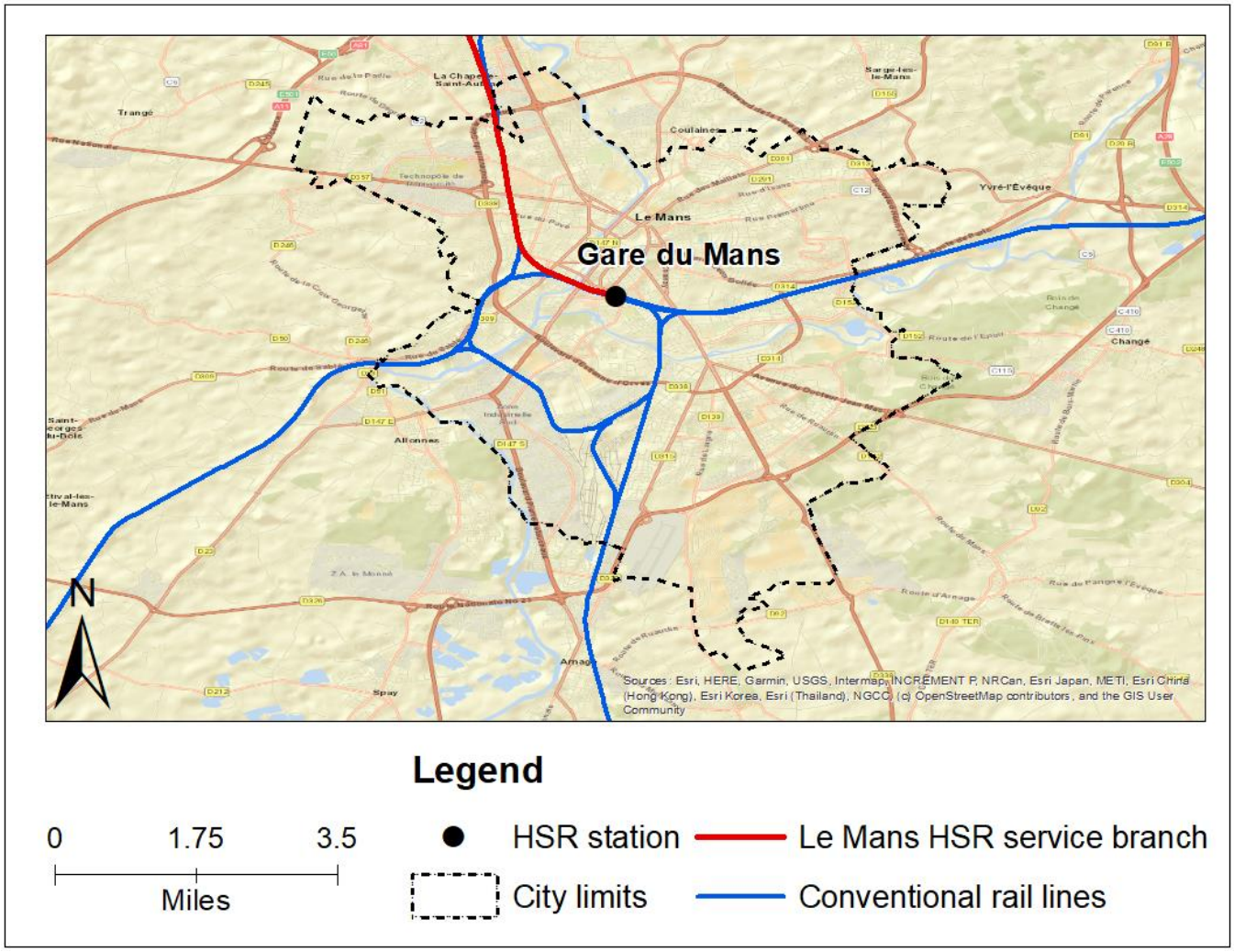

Figure 8. Le Mans' railway stations.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021), SNCF Réseau (2021)

Note: HSR lines in operation are represented in red; conventional lines in blue.

High-Speed Rail Service and Station

Le Mans is located on the Atlantic HSR line and has been served by HSR since 1989 (59). Former president François Mitterrand pushed for the building of an Atlantic line at a time when western France had been largely neglected by rail development (96). This line, in contrast to its South East HSR predecessor connecting Lyon to Paris, is formed as a Y instead of a linear segment (See Figure 7). The development of the line signifies a changing perception regarding the function of HSR. While high-speed rail in France was initially planned as a

means to link two metropolitan areas with a faster transportation connection, in later phases of the development network authorities also started to see its potential for regional economic development (96).

However, the discourse and perception that HSR service automatically results in local economic development, once popular in France, has slowly been evolving (96). In Le Mans, authorities were proactive in developing policies to boost HSR-related economic development, since it had become clear that HSR service alone could not bring such development, and complementary policies were necessary (96). Especially since they saw in HSR an opportunity to develop Le Mans, local authorities insisted upon obtaining HSR service through a central station rather than a peripheral one (97), which is a common way for French medium-sized cities to be served by HSR (39). They succeeded in this effort, and Le Mans' HSR is located at the center of the city. The station was built next to the historical railway station that served conventional rail, and which alone could not have handled the HSR-induced growth in traffic (59). The central station is served by a complementary branch of conventional railway to avoid the Atlantic HSR line being interrupted or detoured for a medium-sized city stop like Le Mans (39) (see Figure 9).

On HSR, Le Mans is now only one hour from Paris. Le Mans was initially located towards the end of the Atlantic HSR line, thus enjoying many daily runs. However, it was expected that in 2017, when the Atlantic HSR line would be extended to Brittany, thus becoming the *Brittany Pays de la Loire* (BRP) line, longer distance travel demand, especially the pressure to compete with air travel, might lead the railway operator to often bypass Le Mans, while traveling to Brittany (39). It seems that this expectation became true, as the number of trains calling in Le Mans has declined recently, so that trains could reach Brittany's cities 10 to 15 minutes faster (98). As a result, there are currently 13 daily round trips from Le Mans to Paris.

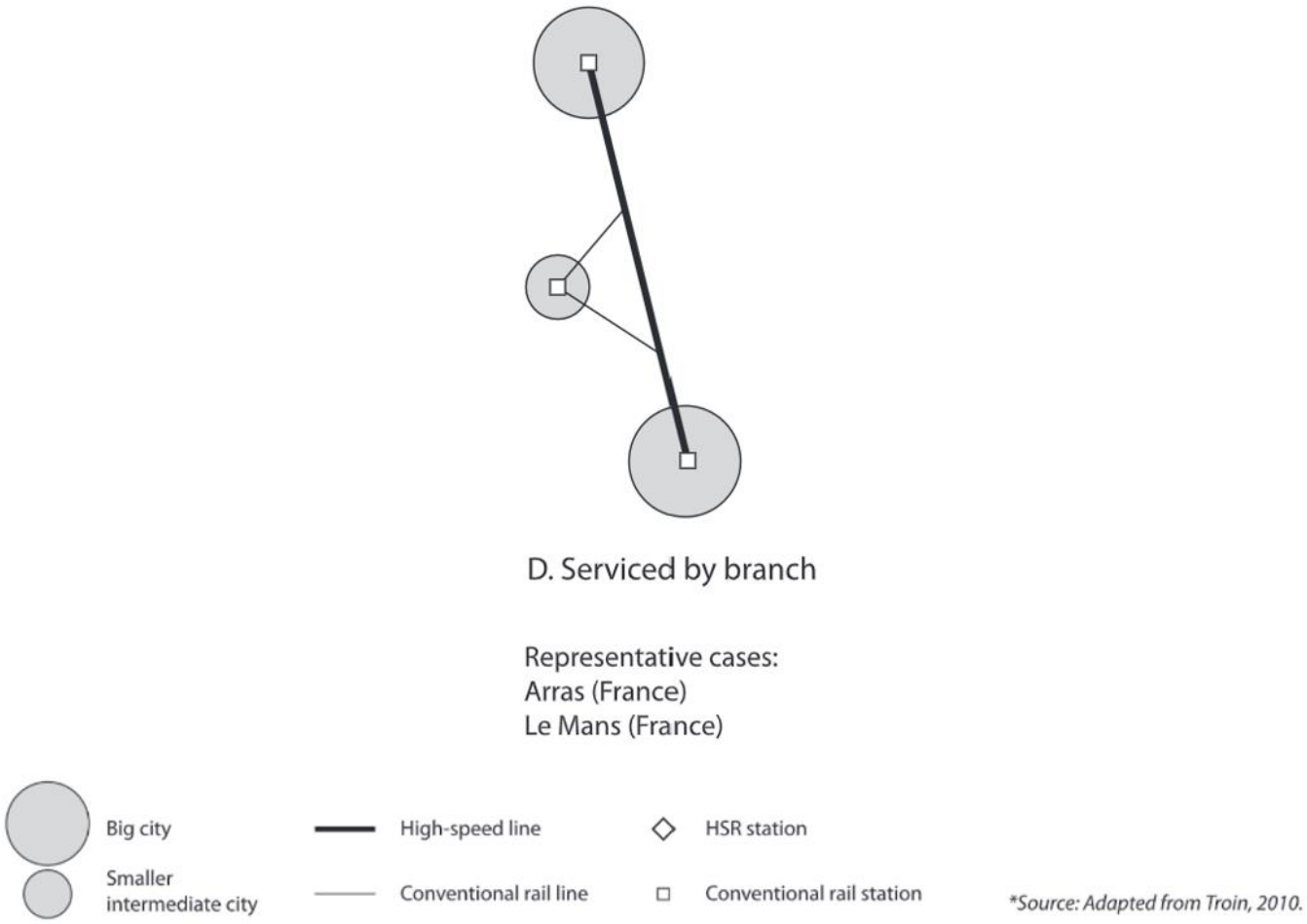

Figure 9. HSR station served by a branch line.

Source: Moyano and Dobruszkes (2017)

Impacts of HSR

In 1987, two years prior to the arrival of HSR, local authorities started preparing strategies to optimize its impact (99). The City of Le Mans, the association of surrounding municipalities, and the Chamber of Commerce formed a committee to plan the creation of a business park adjacent to the station (99). Hence, the arrival of HSR helped start a productive collaboration between diverse public and private interests to enable redevelopment around the stations (100), leading to the creation of a new business park (97).

This business park—Novaxis—built adjacent to the station, was partly completed prior to the initiation of HSR service (100). Novaxis was built particularly fast compared to business parks around other HSR stations (97). Novaxis hosts 60,000 square meters (about 646,000 sq. ft.) of office space (99). A hotel and additional buildings for housing and offices were added in 1996 (97). The business park promoted the renewal of formerly abandoned areas south of the rail tracks (59); it became part of a larger "technopolitan" project promoting the

development of new technologies and technological parks, led by local authorities in an effort to boost HSR's economic development potential (97). This project, which accompanied the arrival of HSR, also led to the creation of two other "technopoles," in addition to Novaxis: 1) "Technopole Université," south of the station, is home to the University of the Maine's campus, which was also expanded as part of the "technopolitan" policies, and 2) "Technoparc," which focuses on attracting companies that have a link to the automotive industry and the city's renown car rally (97). Overall, these three projects spurred the development of three engineering schools, a high school, a community center, a mall and new housing units (99). In addition to these three technopoles, in 2013, the Novaxud eco-district development, a mixed-use neighborhood with office spaces, housing, and university buildings, was begun next to Novaxis (101).

Prior to the completion of the business park, the city had difficulty attracting companies (97). However, the business park attracted 50 companies, mostly local ones initially, but eventually firms from Paris as well (59). The initial difficulty luring firms, and especially Paris-area firms, to the industrial park partly stemmed from the 1993 economic recession in the country. The attracted firms, however, stayed (102), and Novaxis hosted 3,250 jobs as of 2019 (100). Between 1991 and 1999, after the arrival of the HSR line, service businesses tripled in central Le Mans (103). Even though this was not necessarily induced by HSR's arrival, firms attracted to the Novaxis business park reflect the changing economic climate. Despite being called a technopole (97), the firms of Novaxis are mostly service-oriented (96).

The Le Mans station is often described as a success because Novaxis has been able to attract new firms and jobs to the city (102). Indeed, HSR service may have helped to boost the attractiveness of Novaxis (and the city), but the business park's good planning and design were also important factors contributing to its success (102). For instance, in 1991, Novaxis was classified as a Zone of Advanced Telecommunication (ZTA) with buildings connected to high performing telecommunications services, which was a particularly attractive element for prospective firms (97).

While Le Mans was originally not known for its tourist assets and had a negative image associated with its industrial past, HSR also brought opportunities for tourism development (93). Prior to the arrival of HSR, a regional body was formed to develop a marketing plan to attract tourism from diverse EU locations and the Paris region, whose households have a higher median income than those of other French regions (93). They created 11 weekend packages, including thematic activities and experiences, as well as a museum of archeology and history of the city. Moreover, they initiated a summer festival of lights, named "la nuit des chimères," (Night of the Chimera) in 2005, to highlight the urban landscape by projecting art onto buildings and monuments (104), attracting about 150,000 visitors annually (104). These new opportunities resulted in an increase in the number of tourists, but the duration of their stays has shortened. This is particularly the case for travelers visiting the city for conferences or events, also called MICE travelers (Meetings Incentives Congress and Events), who increasingly utilize the business center. Upon the arrival of the HSR line and between 1987 and 1993, their numbers doubled, but they stayed on average only 1.5 days, while travelers who were in town for similar reasons used to stay two or three days. Seventy percent of these business travelers come from the Paris region (93).

Approximately one thousand individuals commute daily from Le Mans to Paris on HSR (105), but the national railway company (SNCF) noticed a decline of professionals making this trip. Instead, increased remote work opportunities post-pandemic combined with Le Man's more affordable housing stock (compared to Paris), have resulted in an increasing number of individuals, especially from Paris, moving to Sarthe County to work remotely and traveling to Paris a couple days per week only (105) (106). This is one explanation for the decline in passenger demand for Le Mans-Paris HSR service, which led SNCF to cancel three daily round trips between the two cities (105). To respond to this change in travel behavior, in 2021, SNCF launched HSR ticket passes, specifically catering to remote workers in a few cities, including Le Mans (107). These newly available ticket passes reflect the proliferation of remote workers living in the area, where they had previously built secondary residences, and are now occupying them more frequently than before (108).

The central location of the Le Mans station has helped make the station a well-connected transportation hub (59). It was easy to integrate the station into existing transportation networks and serve it with multiple bus lanes and a tramway that started operating in 2007. As a result, more than a quarter of the station users access it via public transportation. This high level of intermodality and connectivity helps meet sustainability goals. Indeed, Novaxud, the eco-district launched near the Novaxis business park (100), was inspired by the principles of sustainable development, including the use of renewable energy sources, a sustainable waste management system, and efficiency-plus buildings (101).

Relevance for California

The case of Le Mans shows that the early mobilization of authorities and the collaboration and coordination of different entities and actors were helpful to successfully plan for the arrival of high-speed rail and the development of a business hub next to the station. The existence of this hub in combination with the new HSR service, which shortened the trip to and from Paris, were instrumental in attracting new firms to the city, thus promoting economic development. Local authorities also saw the opportunity to use HSR service to promote tourism and were proactive in planning and initiating a number of attractive tourist activities. Lastly, the pandemic increased remote working opportunities and reduced the time that employees need to be physically in the office. These combined with the fact that the city is only one hour away from Paris on HSR, have helped to increase the number of people moving to Le Mans, and living and working remotely from there. Additionally, Le Mans station's intermodality and centrality enable HSR riders to reach the station easily via public transportation.

These lessons may be relevant for exurban cities on the California HSR, such as Palmdale or Gilroy, that are located on the outskirts of large metropolitan areas. Such cities may consider activities that are synergistic to high-speed rail and can help increase their development potential. In Le Mans, despite the city's prior industrial image, local authorities successfully promoted cultural and business tourism from Paris by initiating a festival, building a museum, and developing an industrial park. Similarly, local authorities in Gilroy, for example, could take advantage of the coming of HSR to rejuvenate and expand their garlic festival, while in Palmdale, the city could boost its aerospace image for tourists interested in aviation and the city's airparks. As the cost of real estate in these two cities is lower than at the center of their respective metropolitan areas, they may also see

an increase in remote workers living there. This would only happen if these cities are perceived as attractive for workers to live in and HSR service is well-integrated into local public transportation networks that connect to other major destinations the workers need or want to travel to.

Reims

City Description

Reims is located in northeastern France, in Marne County of the Grand Est region, 93 miles from Paris. The Reims urban area had 322,264 residents in 2015 (109). Within this large area, the Reims urban unit, which includes the city center and immediately neighboring towns, has 215,275 residents. Its density of 2015,7 residents/km2 (110) makes it the densest French urban unit after Paris (86). Since 2012, the unit includes Bezannes village, where one of the two Reims HSR stations is located. This village has 2,978 residents (111).

Reims is known for its architectural, cultural, and historical heritage. The city played a significant role in French history as its Cathedral, now a UNESCO world heritage site, was used to host kings' coronations (112). The city is also associated with champagne production and export, having 13 Gallo-Roman champagne wineries (113). Currently, the economy of Reims focuses primarily on the service sector: 48 percent of residents employed in the Reims urban unit work in commerce, transportation, or other services (109). Unlike Châlons-en-Champagne, Reims is not Marne county's capital, which explains the city's smaller public sector activity.

High-Speed Rail Service and Stations

Reims is served by the East European HSR line (Figure 10), which was built in two phases, the first one completed in June 2007 (114). This lineserves northeastern France and provides fast access to certain international destinations (114). The line connects with Germany's HSR system and also reaches Switzerland and Luxembourg via conventional lines. Prior to the development of Phase 2, Reims was the only Champagne-Ardenne city directly served by HSR, while destinations such as Strasbourg were only served via conventional lines. This changed when Phase 2 was completed in 2016.

HSR serves Reims via two complementary stations. The city's historic station is located in the central Clairmarais district and is a 45-minute ride on HSR from the East Station of Paris. There are currently about eight round trips to Paris during weekdays from this station (115). In addition to HSR service, this central station is also served by regional trains (TERs) (109).

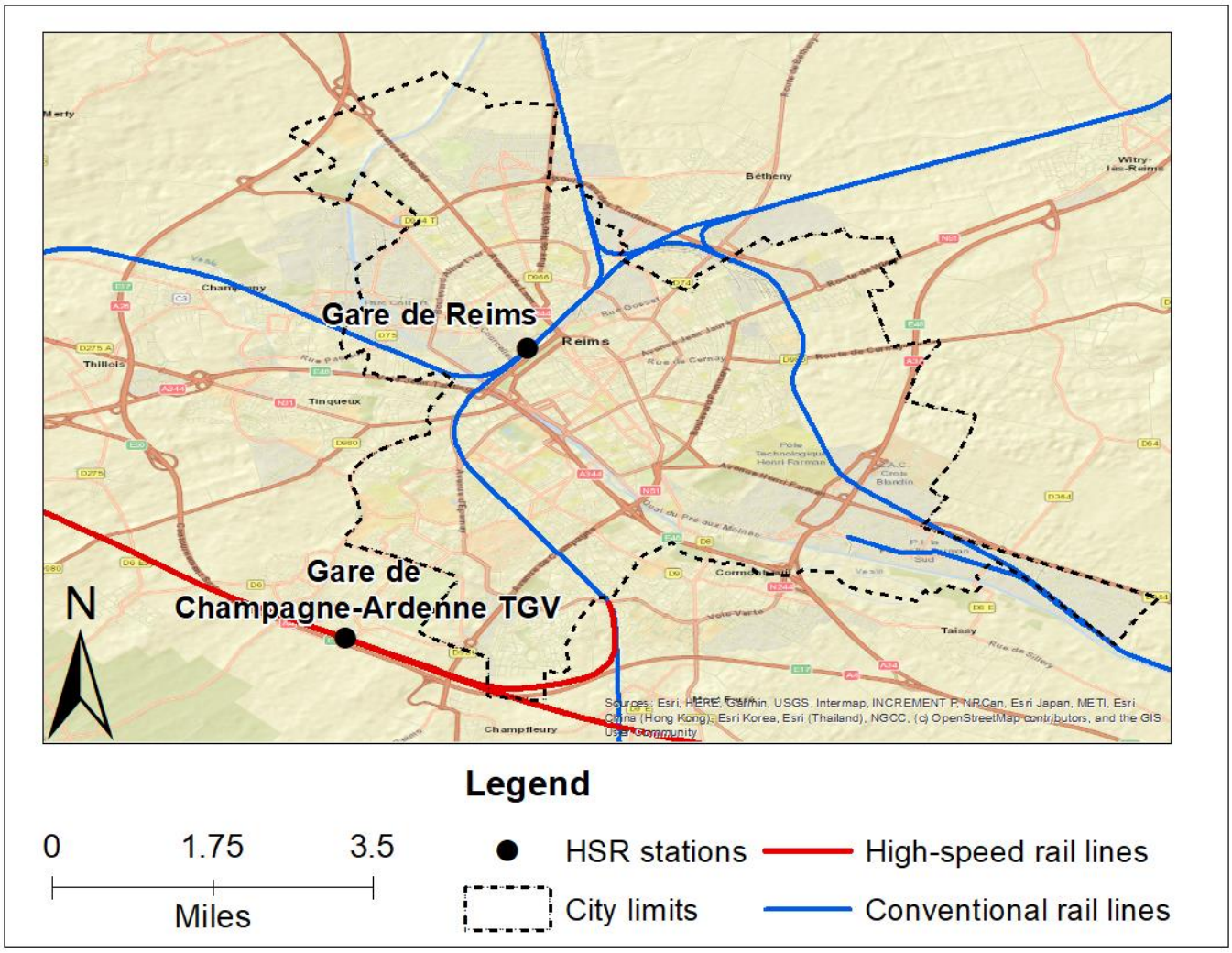

Figure 10. Reims' two high speed rail stations in the Clairmarais district and Bezannes village.

Source: SNCF

Since 2011, the central station has been connected to its new peripheral neighbor, the Champagne-Ardenne TGV station (Figure 11), by both regional train and a tramway (109). This new station, served by the East European HSR line, opened in 2007, is located in the rural village of Bezannes, 500 meters outside of the southwestern part of the Reims urban area, on formerly vacant land (109). Its main role was initially to serve cities other than Paris (116), including ones in the Parisian periphery, such as the Charles de Gaulles airport station (109). However, today, this station also has eight daily HSR round trip connections to the East Station of Paris, which can be reached in 40 minutes.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021), SNCF Réseau (2021).

Impacts of HSR

In 2004, Bezannes' mayor and Reims district authorities created a "Zone d'aménagement concertée" (ZAC), a special planning district to promote and facilitate the development of a business park around the upcoming Champagne Ardenne TGV Bezannes station (117) (109). The ZAC project occupies 172 hectares of land and was to dedicate one third of this land to housing, one third to 300,000 m2 (about 3,230,00 sq. ft.) of office space, and the remaining third to greenery and public spaces for recreation and leisure (109). The goal was to create a complete neighborhood offering a diverse set of services (118).

However, development around the peripheral station was delayed compared to other developments surrounding the central station. Even before high-speed rail's arrival, public authorities had actively worked to redevelop the Clairmarais neighborhood surrounding the central station, which became a mixed-use business district with housing units (115). Construction adjacent to Champagne Ardenne TGV only began in 2010 (117). It took four to six years after the arrival of HSR service for the housing and offices to be completed (117). The archeological reviews going on at the site and primarily the 2008 economic crisis were responsible for this delay (109). Developers slowed or canceled their plans around the peripheral station due to the economic uncertainty, while they maintained their projects around the central station (109). This experience shows that building in a central location is deemed less risky and more reassuring for developers and investors in times of economic uncertainty (109). However, construction and commercialization eventually began around the peripheral station. Offices were first built along with a park and a golf course and were later supplemented by housing (118). HSR was influential in driving the new development around the Bezannes station, making this station location attractive, especially for firms (117).

The East European HSR line arrival came with some economic expectations in Reims given the city's lack of administrative activities, research and development activities or metropolitan functions compared to similar urban areas (109). Prior to the arrival of HSR, a survey of managers of local companies revealed that 85 percent believed that the HSR line would result in positive economic development and a strengthening of the city's position (119). However, the new firms expected to locate around the Bezannes station were slow to arrive, especially because office construction was delayed by the 2008 crisis. Also, the Bezannes business park was competing with other similar facilities in the Reims area (117). Firm attraction is sensitive to the economic climate and can be slow (117). Thus, it was only in 2011 that internal relocations began around the peripheral station, before slowing down, only to restart in 2013-2014 (109). Similar to the central station, the peripheral station mostly attracted local firms as opposed to external ones. However, the Champagne-Ardenne TGV station uniquely attracted larger firms and a significant number of industrial activities, which represented 24 percent of the local companies recently surveyed (109). They include activities such as industrial headquarters, scientific/technical activities, administrative/support and accommodation/catering services (117). Meanwhile, 38 percent of firms around the central station are high-level service activities, such as financial or insurance services (109). The preference of large industrial firms for locating around the peripheral station could be explained by the availability there of larger rental spaces at a lower cost (117). In addition to these industrial

firms, in 2018, one of the largest private hospitals in France, the Polyclinique Reims Bezannes, covering 45,000 m2 (484,376 sq. ft.) moved to the ZAC (120). Those employed by these diverse establishments generated demand for new services, hence a bank, a bakery, and an employment center successively were established at the site (118). However, there is still a lack of certain services, such as a postal office (121), for the ZAC to become a "real" neighborhood (118).

Many of these firms choose to locate near the station not because of the easy HSR connections and accessibility, but mostly because of the large office space availability in the station area (117). Indeed, a survey of firms located around the peripheral station showed that only 12 percent of them mentioned HSR access as their prime location factor. HSR is not used as frequently by employees of Bezannes' firms as it is by the employees of firms around the central station, whose managers regularly travel to the company headquarters in Paris (109). This is a recent practice, since in 2008 only few Clairmarais district employees used HSR (122). Since the arrival of HSR, in addition to these Reims workers often traveling to Paris, there is a growing number of Reims-based individuals who work in Paris daily and commute on HSR. One year after the arrival of HSR, the SNCF already counted 600 riders taking the daily roundtrip (114).

HSR was expected to generate an immediate steep increase in land values and rents, but the real estate housing market remained stable (123). Housing prices in Reims only increased in the past two years, with a five percent increase in 2021 (124). It seems that real estate investors have been slow to anticipate the arrival of HSR and only started purchasing housing units when station construction began (116). Thus, HSR only contributed to an increase in housing speculation for very localized areas near the central station (116). Meanwhile, around the peripheral station, housing prices remained stable and were lower than the prices around the central station, despite the area becoming more attractive thanks to increased amenities and accessibility (124). However, in 2021-2022 realtors noted some increase in Bezannes housing prices, although they suspect it might be temporary (124).

Tourism along the HSR corridor (125), especially in Reims where tourist assets are concentrated, did not develop as expected because local stakeholders failed to coordinate their strategies. For instance, they did not communicate a coherent image of Reims, sometimes highlighting its historic heritage, other times promoting its multiple ongoing construction projects. They also did not consistently provide tourists with regular events, increased hotel space, dining opportunities or signage to guide them to heritage sites (113). Reims lost overnight stays between 2006 and 2008 (126), perhaps because HSR shortened the average trip length to/from Paris. A positive element of the HSR stations in Reims was their intermodality, making access to the city center and heritage sites easy for train travelers, even via the peripheral station since there is a tramway connection to the center (127).

The Champagne Ardenne TGV station is well integrated into the Reims public transport network, especially because it is not located too far from the city center (59), and because local authorities participated in financing public transport (128). Since 2011, the city center can be reached directly from the peripheral station by tram (86). Those who reach the station via public transport, mostly do so by choice, which suggests they are satisfied with the public transport options connecting the station (128).

However, 65 percent of its users still reach the peripheral station by private automobile, while the central station is reached by public transport by 40 percent of its users (59). The peripheral station was well integrated into the road infrastructure and is easily accessible by car (128). New roads were built to easily reach Champagne Ardenne TGV without having to go through Bezannes village (125). Additionally, 700 parking spaces became available (86), which was appreciated by firms around the station (117) and HSR users. Travelers with higher incomes or traveling for business purposes are especially likely to reach the station by private vehicle (128). Meanwhile, reaching the peripheral station by bike or walking is not easy (128).

Relevance for California

In the Reims area, the arrival of HSR led to the creation of a mixed-use neighborhood surrounding the peripheral station with diverse services, office space, and housing units. This newly-developed district attracted new residents and larger industrial firms as opposed to the smaller tertiary firms near the central station. This implies that peripheral California HSR station-cities, such as Palmdale, may also attract larger industrial firms in search of cheaper office space than in central Los Angeles.

The Reims experience, however, also reveals that centrality is reassuring to firms and developers. During the 2008 crisis, building development and the establishment of new firms around the peripheral station slowed down, which did not happen around the central station. It is possible that developments around peripheral California stations could also be similarly sensitive to economic conditions.

In terms of tourism, local promoters failed to seize Reims' potential. They did not coordinate communication strategies and did not push for the expansion of hotel spaces, touristic events, etc. Similar to other case studies, this reminds that having HSR service per se is not enough to promote tourism development; local actors need to coordinate, determine tourist needs, and prepare accordingly.

The Champagne-Ardenne TGV station is easily accessible via public transport options. While it is still mostly reached by private vehicles, the percentage of those accessing the station via automobile is lower than in older French peripheral stations planned without satisfactory public transport options, such as Le Creusot. This is a reminder of the importance of developing alternative (green) mobility options for HSR stations as a way for peripheral California stations to reduce automobile dependence.

Summary of Impacts in France

Table 5 presents a summary of the HSR impacts on each of the case study cities in France.

Table 5. Summary of HSR impacts on French station-cities

Case Study	Social impact	Economic impact	Physical impact	Environmental impact	Policy impact
Le Creusot	Students and low-income populations have inadequate public transportation options to reach HSR station (128).	The Coriolis business park was only able to attract a disappointingly low number of firms (79). The business park did not create as many local jobs as expected (71). Coriolis employees travel frequently for business purposes (74).	The Coriolis business park was developed adjacent to the HSR station (74).	The station is primarily accessed by private automobile (78).	Local authorities have agreed on the necessity to improve the attraction of the business park and plans are underway (79).
Le Mans	A dormitory effect with workers that live in Le Mans and commute to Paris has appeared, though this has been reduced (and partially reversed) with remote work opportunities becoming more common (104).	The Novaxis business park was able to attract new companies and jobs to the city (59). The attracted firms are mostly service-oriented (95). High-speed rail brought opportunities for tourism development (92) but conference and business travelers' average stay length shortened (92).	The Novaxis business park was built adjacent to the station (100). The "Technopole Université" was created (97). The "Technoparc" hosts companies linked to the automotive industry (97). The Novaxud eco-district was created following principles of sustainable development (101).	The central station location facilitated integration with the existing public transportation network (59).	Public and private actors collaborated to prepare for HSR arrival and benefited from it (98).

Case Study	Social impact	Economic impact	Physical impact	Environmental impact	Policy impact
Vendôme	Housing costs for local residents increased due to the pressure brought on the housing market by newcomers (92). A dormitory effect occurred between Paris and Vendôme (91).	Le Bois de l'Oratoire business park initially struggled to attract external companies. Later on, between 50-70% of the firms that relocated in the park came from other regions (86). Only 450 jobs were created in Le Bois de l'Oratoire when 5,000 were expected (74). There was a substantial failure to develop tourism as initially hoped for (74).	The Le Bois de l'Oratoire business park was built adjacent to the HSR station (74).	The station is poorly connected with the city center via public transportation (70). While the site surrounding the station was supposed to host non-polluting activities, this did not happen (67).	N/A
Reims central station (Gare de Reims)	A dormitory effect appeared between Reims and Paris (113).	Developments and relocation of firms near the station were not slowed down by 2008 economic climate (116) (108). Firms that settled near the station are mostly local high-level service activities (108) Tourism development post high-speed rail arrival was disappointing (112).	Both a business district behind the station as well as housing were built (115).	The station is very well integrated into public transportation networks, 40% of users reach it via public transportation (59).	Public authorities were actively involved in revitalizing the station district (115).

Case Study	Social impact	Economic impact	Physical impact	Environmental impact	Policy impact
Reims peripheral station (Champagne-Ardenne TGV)		The attraction of firms and the completion of developments near the peripheral station slowed down with the economic climate in 2008 (116) (108). However, in later years constructions eventually resumed near the station (117). Firms that settled around the station are large local firms. There is a large presence of industrial activities (108).	Offices, housing, a park, a golf course, a large hospital and neighborhood shops appeared near the peripheral station (119) (117).	Archeological reviews delayed development (32). The station is easily reachable via public transportation and road but not by walking or biking. 65% of users come by private automobile (128) (59) (85). High-income travelers tend to reach the station by private car (128).	Creation of a special planning district (ZAC) adjacent to the station prior to high-speed rail arrival helped facilitate new development (116) (108). Local authorities participated in the financing of public transportation options serving the station (127).

Spain

Spain began its development of high-speed rail in 1992. The first corridor was inaugurated for the Expo in 1992 and connected Madrid and Sevilla.

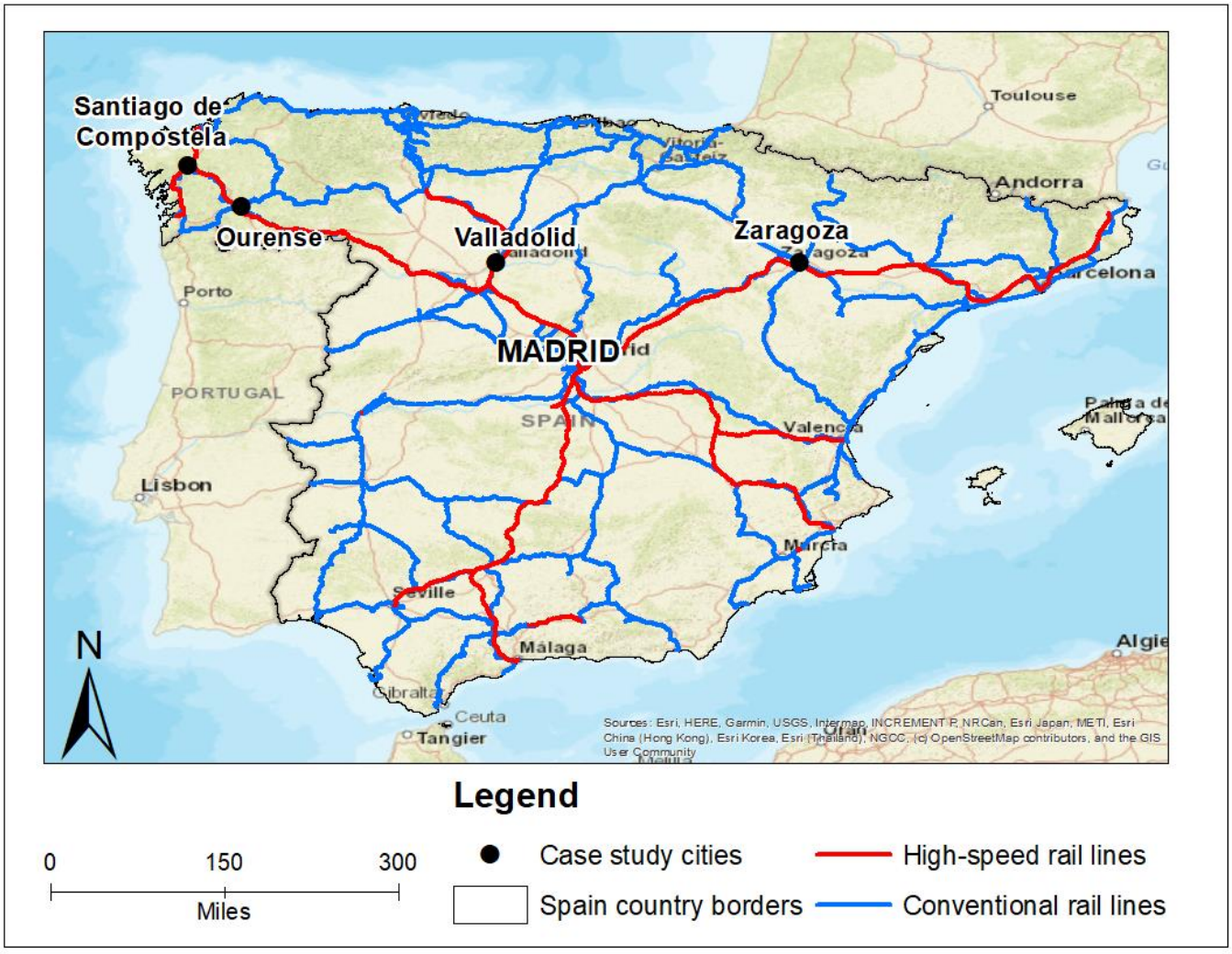

Figure 12. Spain's high speed rail network.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021) OpenData Esri España (2023), Red de ferrocarriles de España.

Note: HSR lines in operation are represented in red; conventional lines in blue.

At the time of this writing, Spain has more than 800 miles of high-speed rail with more than 30 stations served by HSR, and it is still expanding its HSR network (Figure 12) (129). In this study, we focus on the corridor connecting Santiago de Compostela and Ourense in Galicia, and the city stations of Valladolid and Zaragoza.

Galicia

Region Description

The Northwest HSR corridor in Spain (Figure 13) is also referred to as the Galicia Corridor as it connects important cities in Galicia, an autonomous region in Spain. This region includes the provinces of A Coruña, Lugo, Ourense and Pontevedra. The main cities of Galicia are Santiago de Compostela (hereafter referred to as Santiago), which is the capital of Galicia, as well as A Coruña, Pontevedra, Ourense, Lugo, Ferrol, and Vigo.

Galicia has a total area of 29,574 square kilometers (11,419 sq. mi.) and a population of 2,701,819 residents (130). This region in northwestern Spain neighbors Portugal and is surrounded by the Atlantic Ocean and Cantabrian Sea to the west and to the north, respectively. Galicia is geographically separated from the rest of Spain by a mountainous area between the communities of Galicia and Castilla y León. This is reflected in the local heritage and cultural identity of the population, which still preserves their Gaelic language and culture.

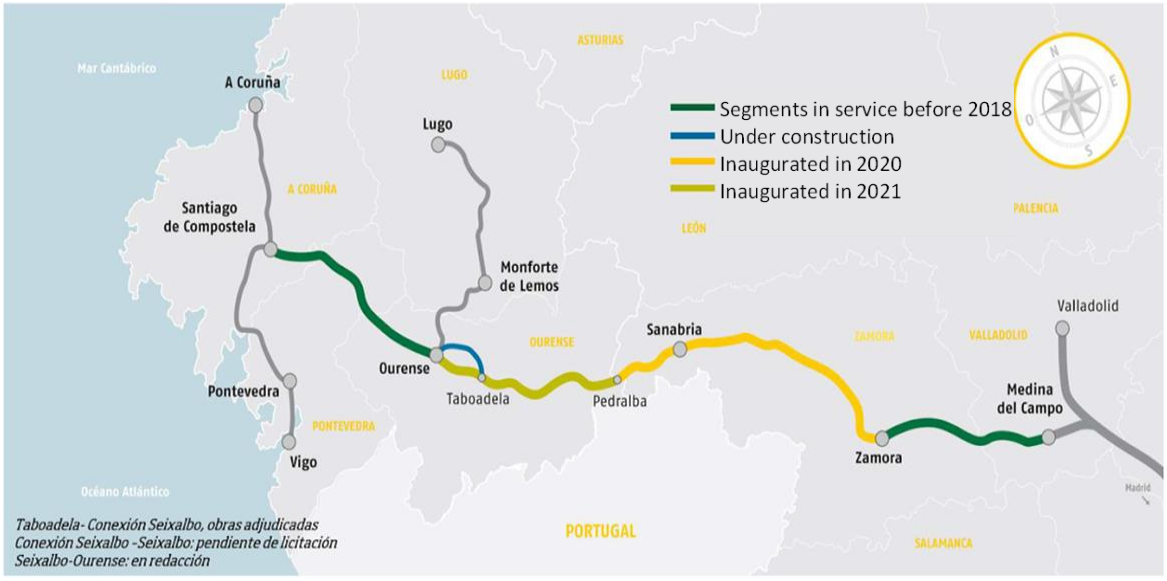

Figure 13. Northwest Spain Corridor.

Source: (Ministry of Transport Spain, 2021)

As Figure 13 shows, the corridor has had different inauguration dates per segment. The first segment of this corridor was built between Santiago de Compostela and Ourense, and the second segment between Zamora and Medina de Ocampo (Olmedo city) (131).

We here focus on the Santiago de Compostela-Ourense section before its connection to the rest of the country's HSR network. The two cities that were connected by this initial corridor in Galicia are Santiago de Compostela and Ourense. Santiago in 2021 had a population of 97,858 residents, and Ourense had a population of 104,596 residents. Santiago hosts a large public university by the same name; it is also a special city as it attracts tourists and is known for its Catholic relics and the pilgrimage of the Camino de Santiago

(132). In 2019, prior to the COVID-19 pandemic, Santiago was visited by over 1,466,000 tourists annually (133).

High-Speed Rail Service and Stations

The first rail service began operations in Galicia in 1873 (134). This early railway corridor included a station in Santiago and connected it to the city Santiago de Carril. This first station was the Santiago Cornes station (134). In 1943, with the inauguration of the La Coruña railway corridor, the Spanish railway operator Renfe closed the old station and constructed a new station at the south border of the city, which is the one currently in use.

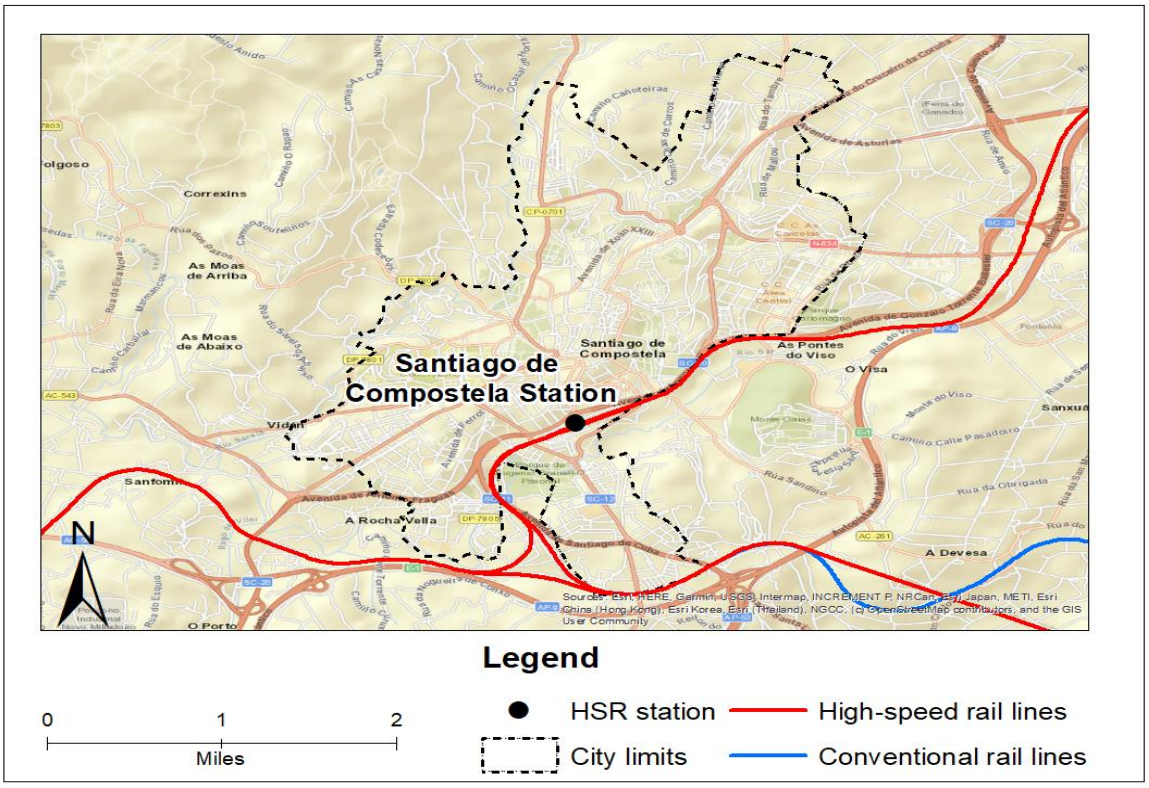

Figure 14. Location of HSR Railway Station in Santiago de Compostela.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021) OpenData Esri España (2023), Red de ferrocarriles de España

The first HSR service between Ourense and Santiago started on December 10, 2011, on a line using Iberic gauge.[1] The investment included the electrification of the Santiago-Coruña segment (38 miles, costing 844.5 million Euros), the improvement of the alignment, and the construction of dual tracks (one in each direction). The corridor is 87 km long and cost 2,100 million Euros; it takes about 34 minutes to travel from Santiago to Ourense (135).

The station in Santiago (Figure 14) is open daily from 4:30 a.m. to 12:30 a.m. (136). It is less than 1.2 km from the city's famous Cathedral (and major landmark in the city), and it can be accessed by walking (16 min.), bicycle (9 min.), car (7 min.), or taxi (7 min.) from the city center, or by bus from more peripheral areas of the city. It is located to the south of the city center and adjacent to the intersection of two main roads, Av. De Lugo and Av. De Romero Donallo. Presently, the train station has four direct daily trains to and from Madrid, seven trains to Ourense, 15 trains to A Coruña, and a couple daily to Ferrol and to Vigo. These include both HSR and conventional rail services.

The station at Ourense (Figure 15), is open from 05:30 a.m. to 11:15 p.m. and can be accessed by walking, bicycles and scooters, car, taxi, or bus (137). The driving distance from Madrid to Santiago is 600 kilometers on the shortest route, and from Madrid to Ourense is 514 kilometers. With the new HSR service, a trip from Ourense to Madrid takes only two hours 15 minutes. The HSR station in Ourense is located at the north side of the city, just north of the river and main access road (N-120).

[1] Most HSR corridors in Spain are being built with or converted to the standard European gauge, 1435 mm. The Iberic standard is wider, at 1668 mm, and is used for the rest of the conventional rail network. The conversion to standard gauge allows for connections to international rail services, for example with France, and can facilitate train interoperability.

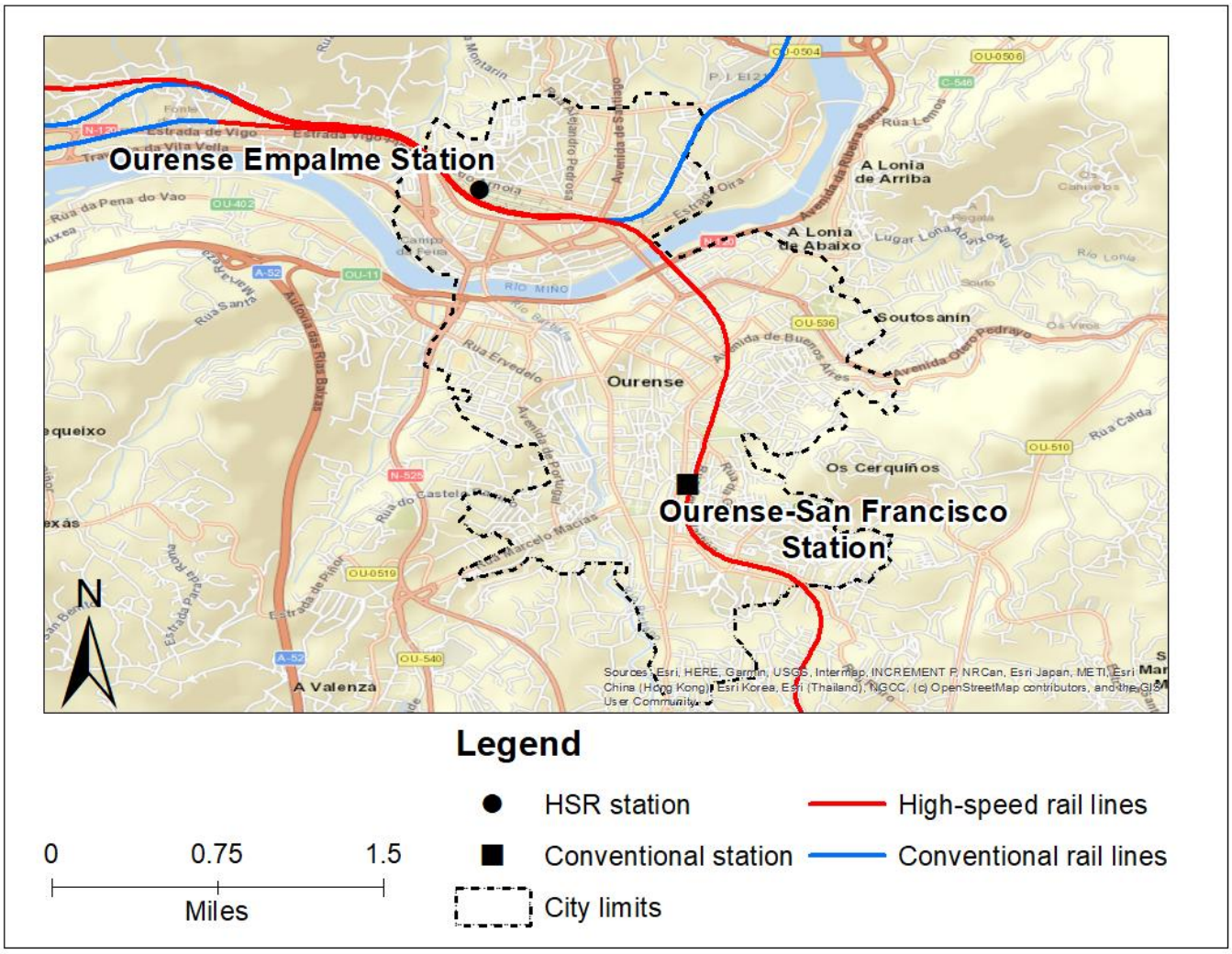

Figure 15. Location of Railway stations in Ourense.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021) OpenData Esri España (2023), Red de ferrocarriles de España.

Note: HSR lines in operation are represented in red; conventional lines in blue.

It should be noted that the operation of this HSR corridor was affected by a train crash in 2013. Human error (and the lack of proper signaling) was the primary cause of the crash, as the train driver took the Alvia train into a curve at more than twice the posted speed limit (138) (139). The official investigative report determined that this crash was preventable (138). The crash resulted in system upgrades and higher signaling standards on this corridor, including the adoption of the European Train Control System (ETCS)/European Rail Traffic Management System (ERTMS) signaling standards, which are being deployed on many European HSR lines, and which may help prevent similar crashes (140).

Impacts of HSR

As with other HSR lines, one of the major impacts of this line is the savings in travel time from Ourense and other cities of Galicia to Santiago. Thanks to the HSR service, Ourense is now less than 40 minutes from Santiago, when before the trip took about one hour 30 minutes (resulting in 50 minutes of travel time saved) (141). This has made Renfe's Avant service the preferred mode of transportation for students and professionals that commute daily to Santiago (142).

Ourense has more residents than Santiago; this can be explained by the fact that, for many years, Santiago was enclosed by walls. Even though these walls have been largely demolished, the development of the city has remained compact because the walls constrained the city's expansion and inflated the cost of housing.

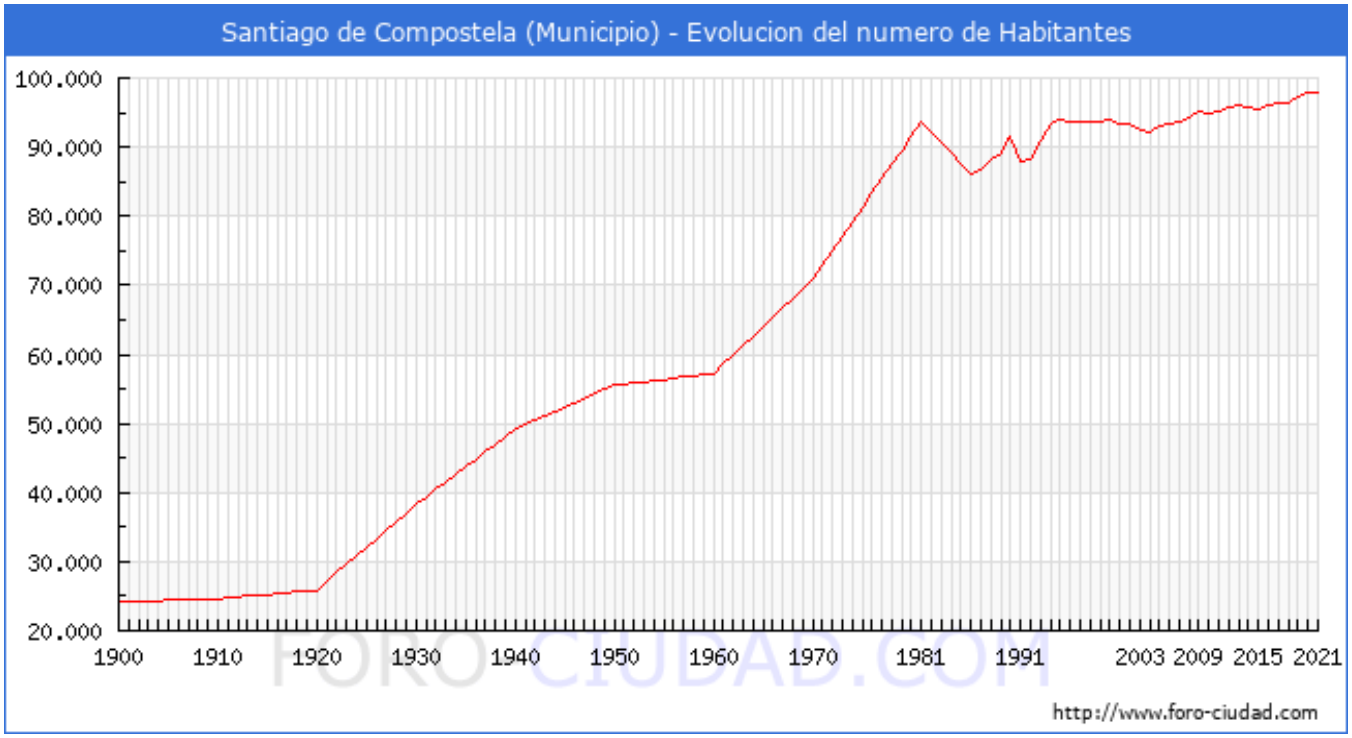

Figure 16. Evolution of population size in Santiago de Compostela 1900-2021.

Source: (Foro- Ciudad.com, 2023)

Since the launch of HSR service in 2011, the population in Santiago has witnessed a slight increase (Figure 16), while the population in Ourense has experienced a slight decrease (Figure 17).

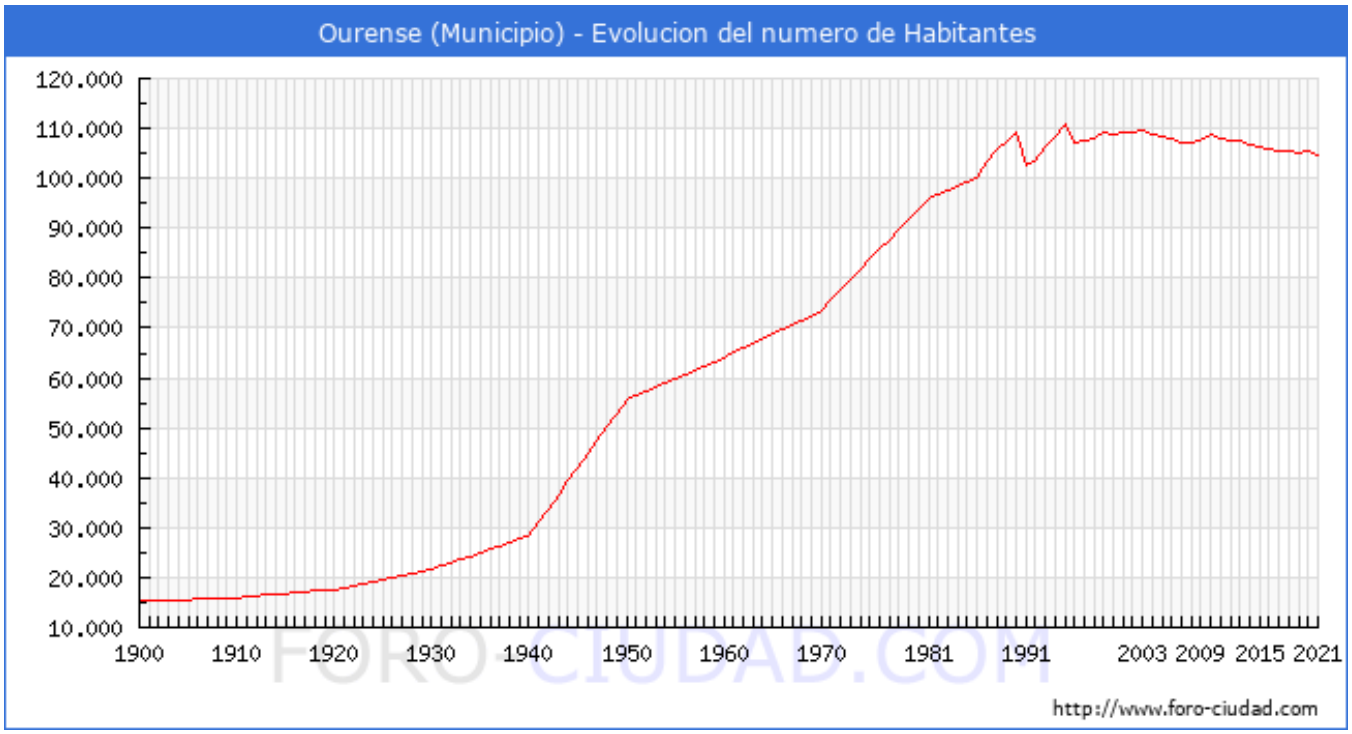

Figure 17. Evolution of population size in Ourense 1900-2021.

Source: (Foro- Ciudad.com, 2023)

In Santiago, the highest density area is located in the south part of the city's downtown area, between one and two km from the HSR station, and near the junction of the major roads coming from the southwest and southeast of the city (Figure 18). In Ourense, the densest areas of the city are around the downtown area, just south of the river (Figure 19).

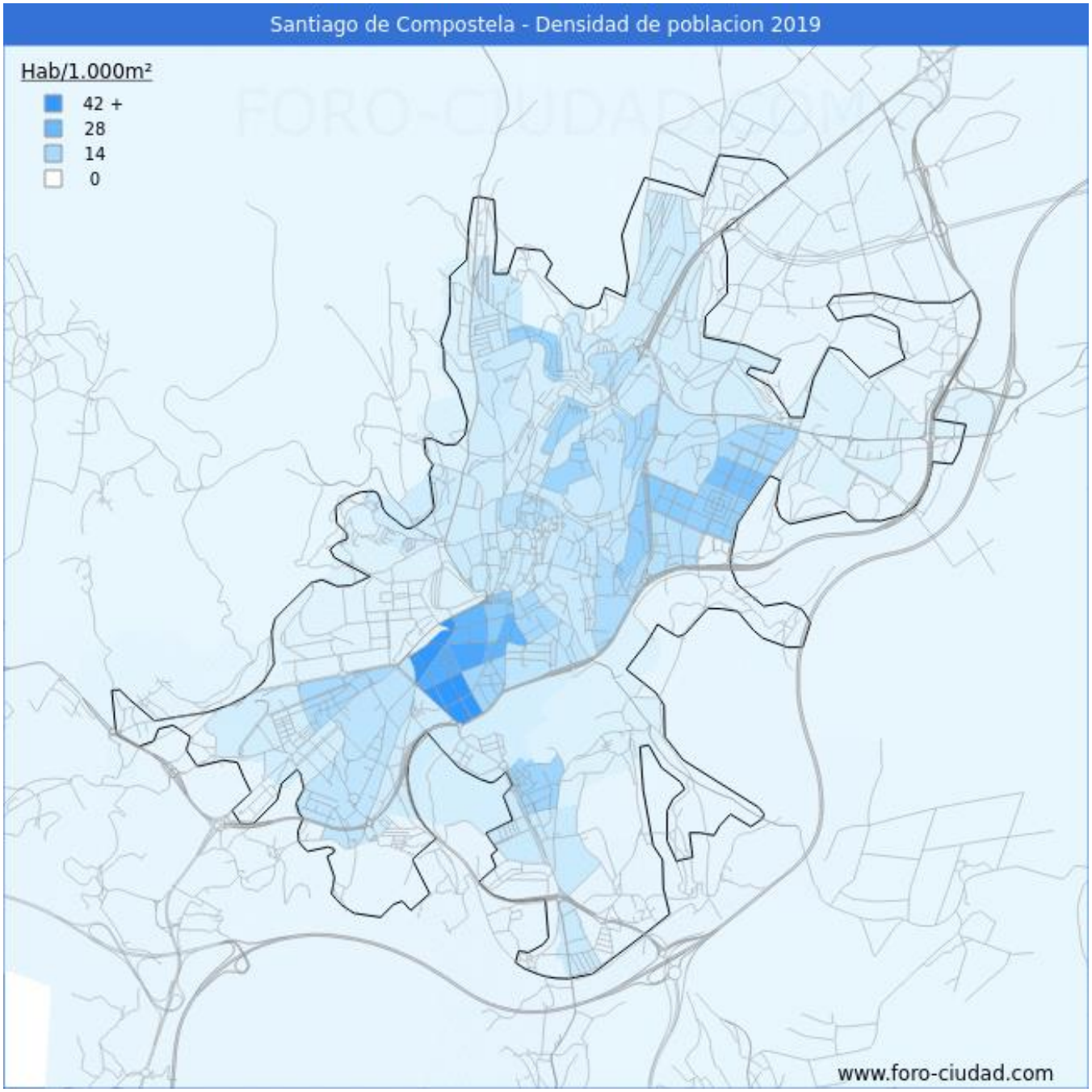

Figure 18. Population density in Santiago de Compostela, 2019.

Source: (Foro- Ciudad.com, 2023)

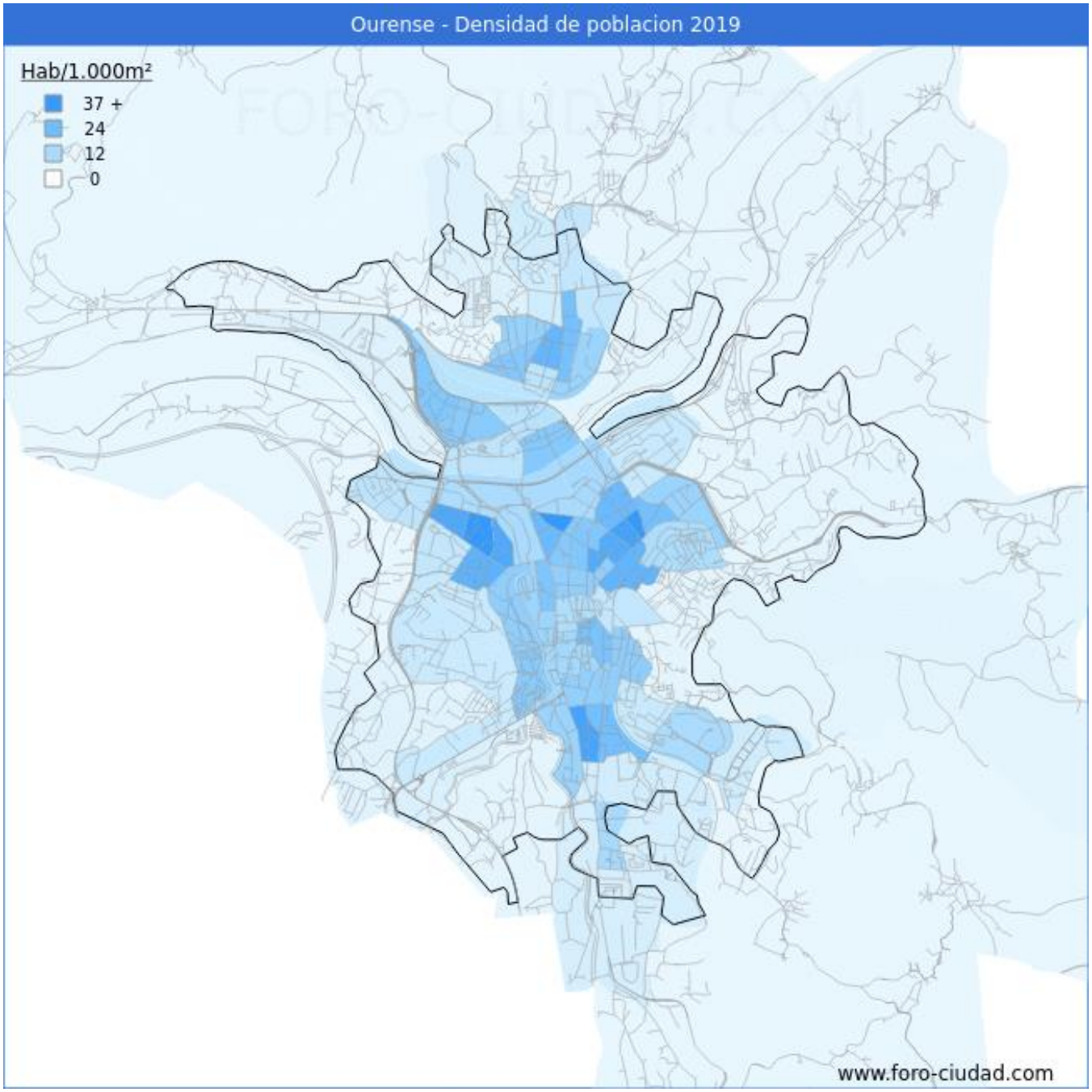

Figure 19. Population density in Ourense, 2019.

Source: (Foro- Ciudad.com, 2023)

Santiago and Ourense, as well as other nearby cities, such as Ferrol and Lugo, present a type of conurbation in which Santiago offers many services as the capital and is the biggest tourist attraction in Galicia, while the

surrounding cities largely serve as dormitory cities (143). The cities have not merged but do function as a group in a complementary way.

Santiago has been a major tourist destination for many years, attracting large numbers of tourists annually. Since the first HSR corridor segment was not connected to major international airports, or other major cities, there is no way to tell how much of an impact the new HSR corridor has had on tourism. However, since the corridor has been recently (in December 2021) connected to Madrid, it will be interesting to examine if this begins to change in future years.

The old city of Santiago has many historic buildings which are protected from demolition, as well as the various pilgrimage routes of Camino de Santiago. There are still traces of the walls of the city in some buildings and the walls have affected the city layout and constrained its development (144). The city of Santiago has far more building conservation restrictions in place than Ourense, limiting the amount and type of development in the city, as well as boosting costs.

Figure 20 and Figure 21 show that real estate costs per square meter in Santiago are higher than Ourense. Prices in both cities peaked between 2011 and 2012, which may be related to the inauguration of the HSR service that connected these cities, as well as to larger economic trends in the region. In both cities, housing prices dropped soon thereafter and have remained lower than in 2011 in the following years (145).

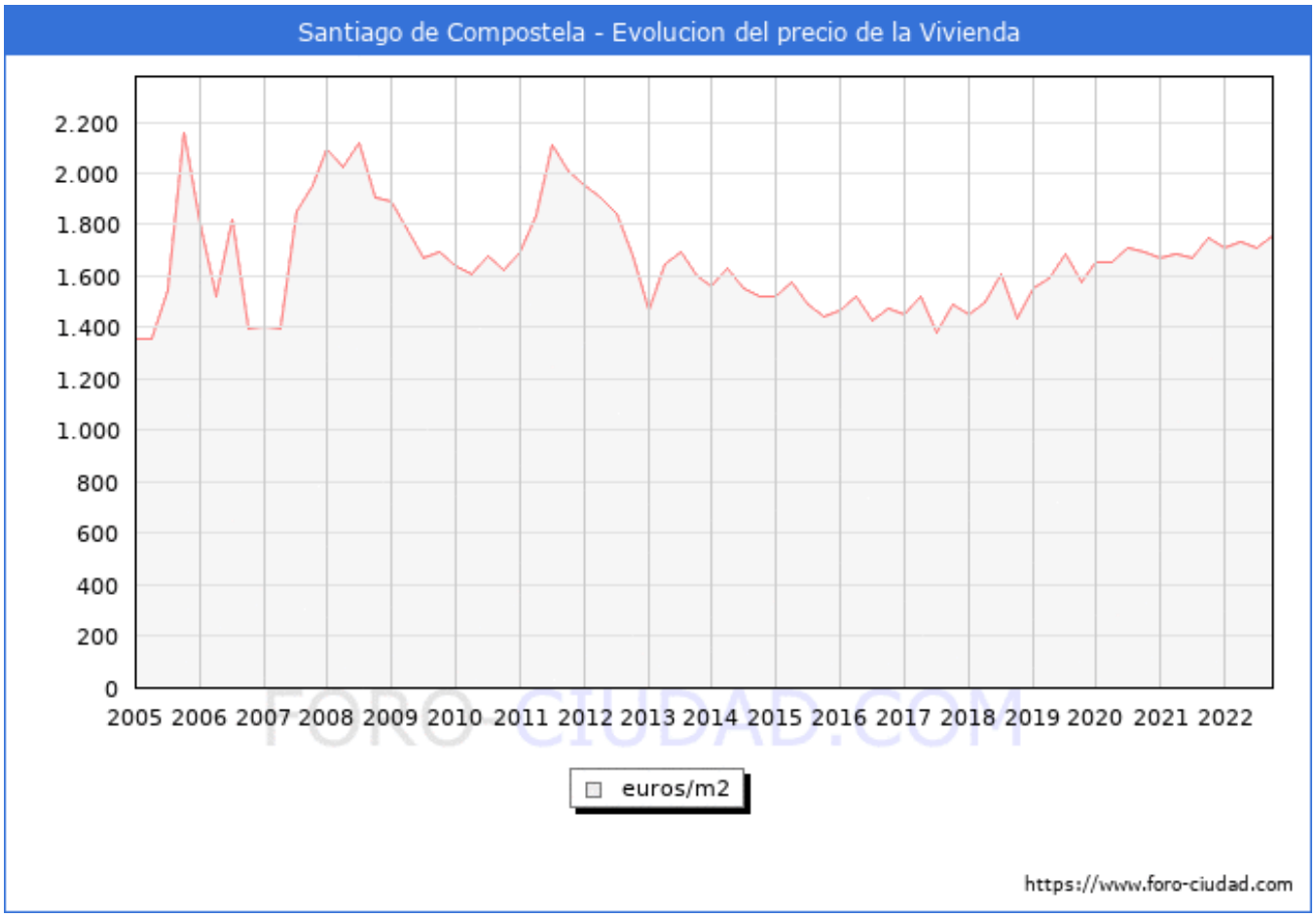

Figure 20. Evolution of real estate prices (Euros per sq. meter) in Santiago de Compostela 2005-2022.

Source: (Foro- Ciudad.com, 2023)

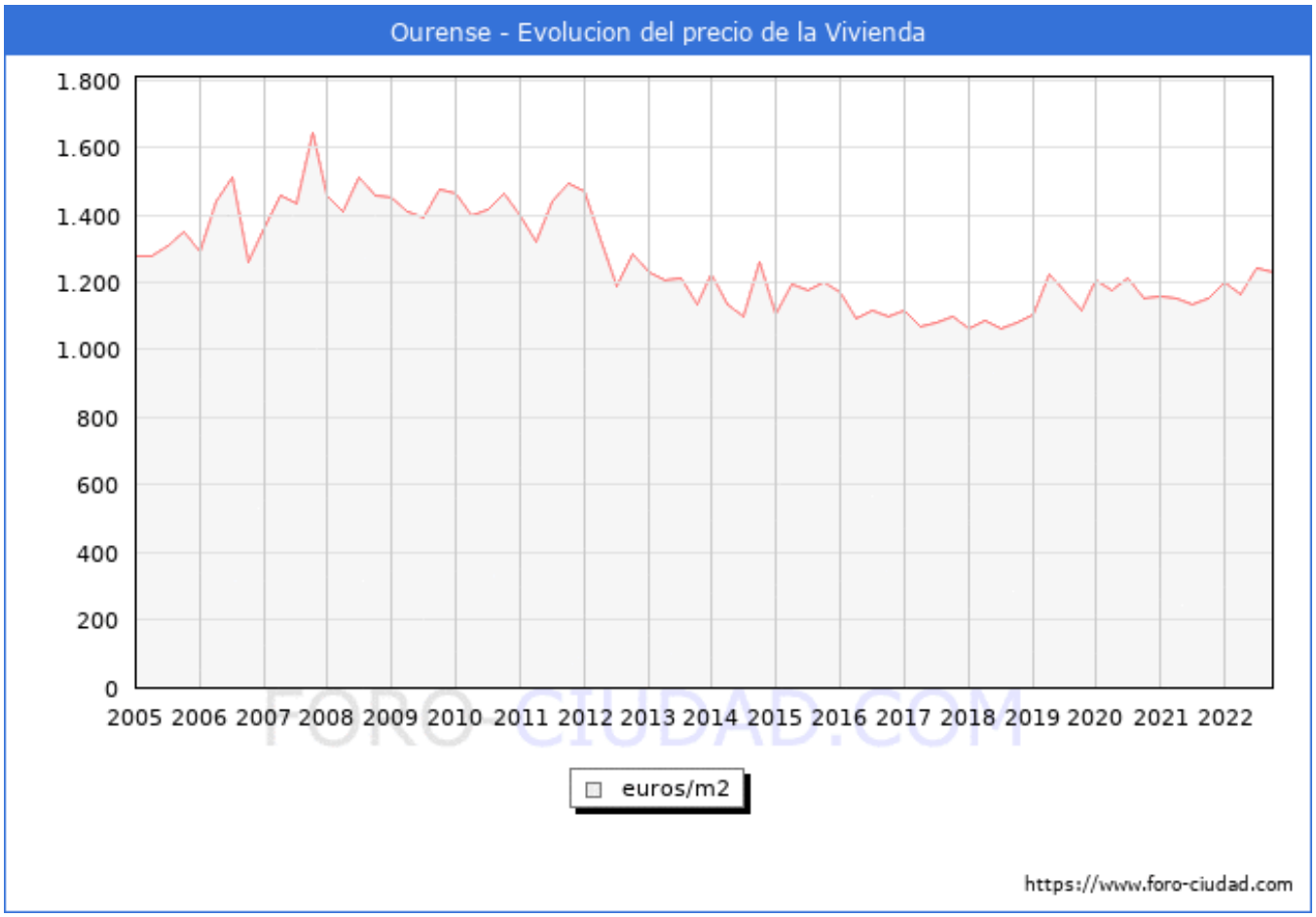

Figure 21. Evolution of real estate prices (Euros per sq. meter) in Ourense 2005-2022.

Source: (Foro- Ciudad.com, 2023)

In Santiago, though the growth in population has been slow, there has been an increase in the number of buildings. As Figure 22 shows, most of the buildings built after the year 2000 (in green and blue) have been located in the peripheral areas of the city and concentrated around its main roads and corridors. We speculate that the developments southeast of the city may have been affected by the launching of the HSR service, as they are directly connected to the station by a straight road and were developed during the decade that the HSR service started. However, this could also be related to urban planning policies and plans that have oriented development to those areas (146).

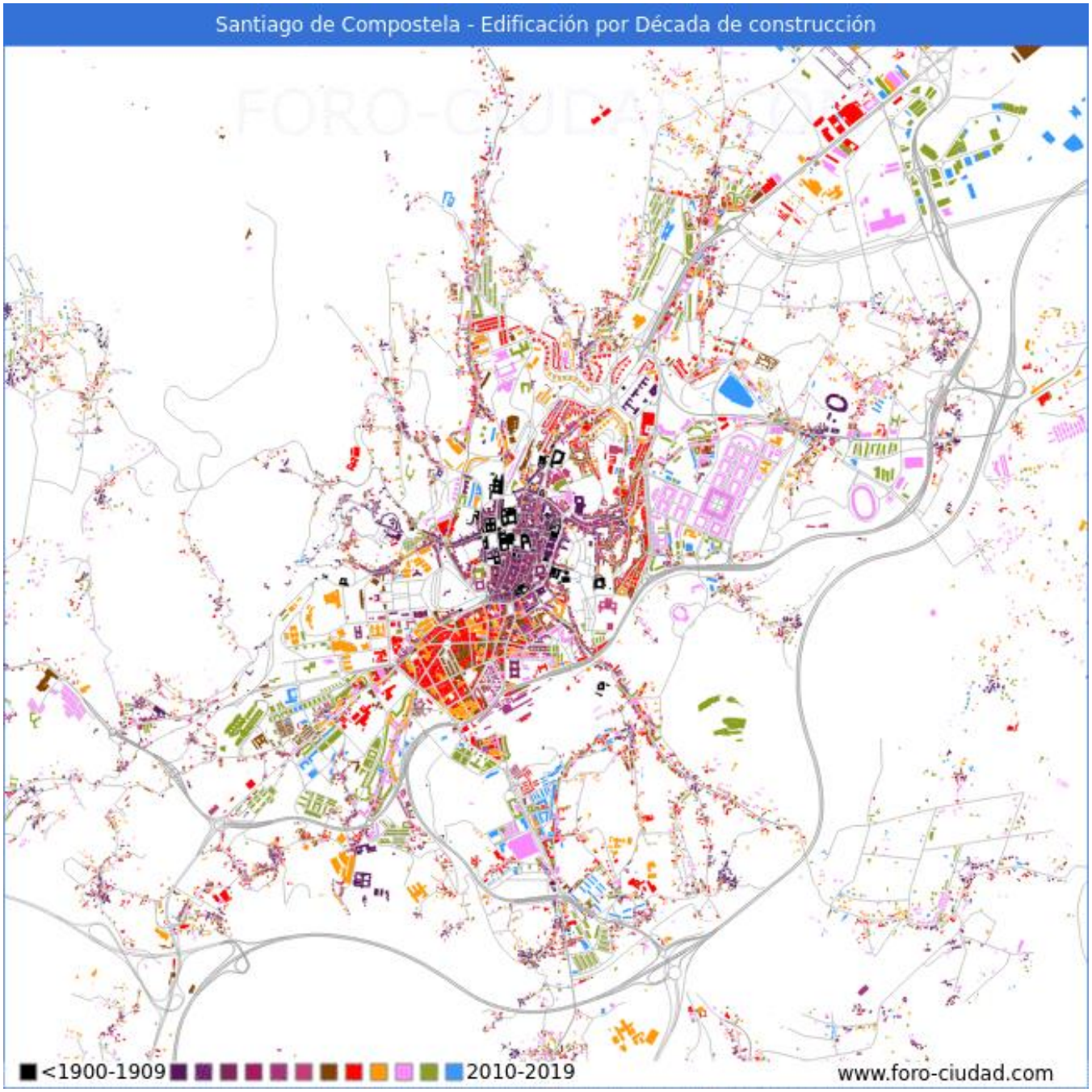

Figure 22. Building per decade of construction in Santiago de Compostela.

Source: (Foro- Ciudad.com, 2023)

Relevance for California

This rail corridor segment was developed initially within the autonomous community of Galicia, without being connected to Madrid or other large Spanish cities. This is similar to the development of the first segment of the California HSR corridor, which for a number of years will remain unconnected to the major metropolitan centers of San Francisco, San Jose and Los Angeles. Both Ourense and Santiago can be considered small metropolitan cities, though Santiago is also the capital city of the autonomous community of Galicia. Additionally, Santiago has a long history of pilgrimage and tourism that makes it an attractive destination in Galicia; even during the COVID-19 pandemic the city attracted nearly one million annual visitors in 2021 (147). These numbers remain below the average annual number of visitors to some of the tourist areas of central California like Yosemite (3.3 million) (148) and Monterey County (4.6 million) (149), which in the future might be affected by their proximity to HSR service, though none of these locations will be directly connected (but could be reached through feeder services from the main HSR network).

Significant impacts from the initial segment of the Northwest HSR corridor have not been documented. This could be the result of this segment's low connectivity to other regions, up to very recently, when it was finally linked to the rest of the HSR network in Spain. This reminds one of the potential of HSR service to achieve better accessibility and connectivity when part of a larger network, but also that this potential might be limited when initial corridors are deployed in isolation (as it will likely be the case for California's HSR service, at least in the initial phase). It will be interesting to examine whether the recent connection of the Galicia corridor segment to the rest of the Spanish HSR network will bring larger economic impacts to Galicia and the city-stations on the corridor. Nevertheless, if the lessons learned from this case study can be applied to California, the example of the Galicia corridor seems to indicate that the initial impacts of the California HSR might be modest, until this segment is connected to the large metropolitan centers of Northern and Southern California.

Valladolid

City Description

Valladolid is the largest city in the Castilla y Leon region and among the 20 most populated cities in Spain. It is the capital city of the province of Valladolid and hosts the main headquarters of Castilla y Leon's courts, board and presidency (150) (151). It is located 161 km north of Madrid, and 572 km (357.5 mi.) west of Barcelona. The city has a population of 302,000 residents, with an area of 197 km2 (76 sq mi) (152) and a population density of 1500 residents/km2 (3900 residents per square mile). The population is aging and has been experiencing a slight annual decline (between 0.3% and 0.7%) since 1990 (153). Valladolid can be described as a small metropolitan city, but an important one as the capital of its province.

It is home to the University of Valladolid, the largest university of Castilla y Leon, and one of the major ones in the country, and several museums like the Christopher Columbus House-Museum and the Museum of Spanish Contemporary Art (154). The city's historic center once housed many important Spanish families, like the house of Cervantes.

Valladolid's economy is mostly focused on the service sector in which 83 percent of the firms in the city operate, followed by construction firms (11%), industrial firms (about 5%) and firms in the agricultural sector (less than 1%) (155). In terms of industry, Valladolid and Palencia have one of the five main car manufacturing factories in Spain (156). Accordingly, 71.8 percent of residents in the labor force work in the service sector, 15.9 percent in the industrial sector, 8.5 percent in construction, and 3.9 percent in the cultural sector (157).

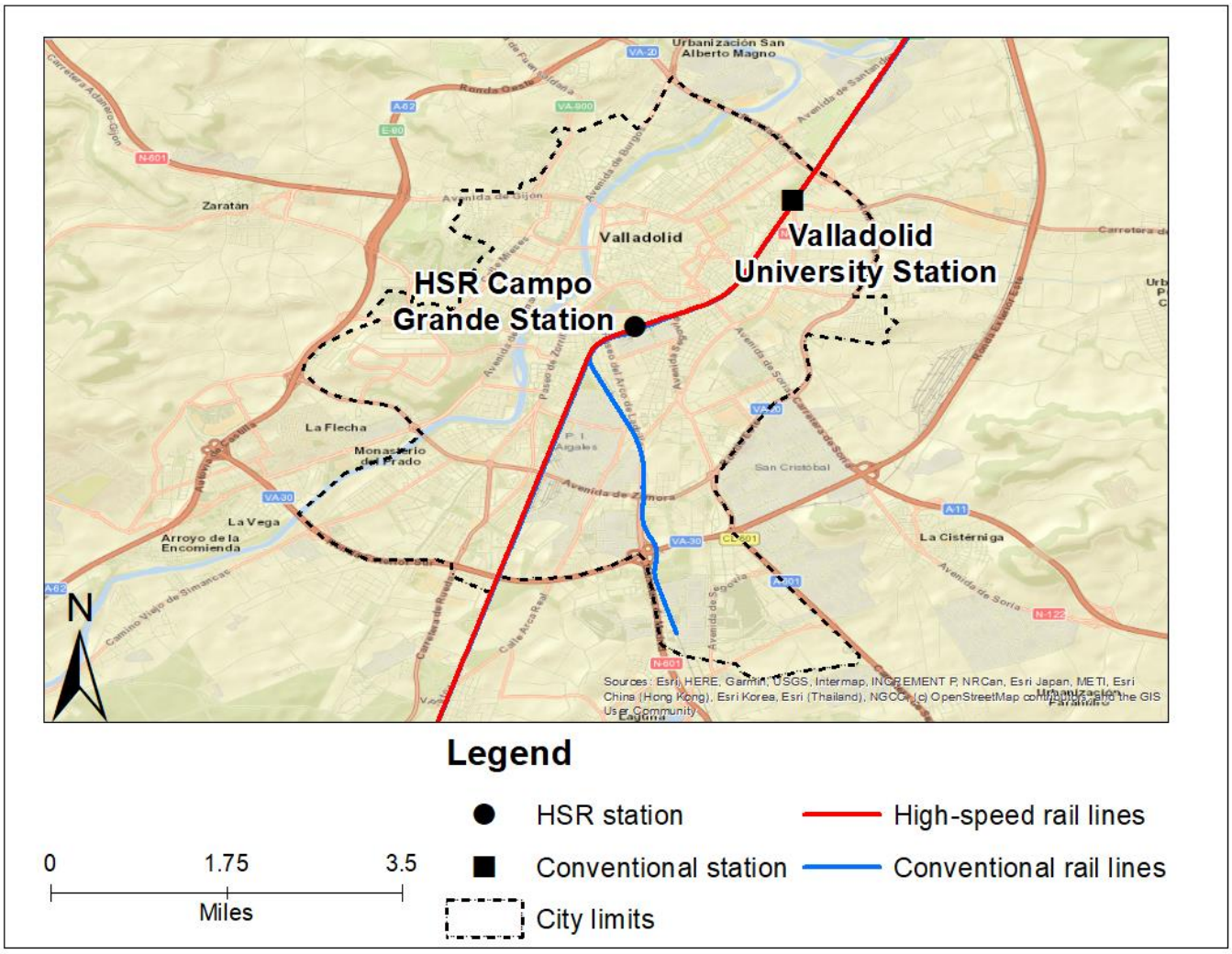

Figure 23. Valladolid city map and train stations.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021) OpenData Esri España (2023), Red de ferrocarriles de España.

Note: HSR lines in operation are represented in red; conventional lines in blue.

High-Speed Rail Service and Stations

The Valladolid Station (Valladolid-Campo Grande) was initially a terminal station of the Madrid-Segovia-Valladolid HSR corridor. It was built in the 1860s and has continued to serve as the main train station of Valladolid, restored and adapted to the new HSR services and trains. The second station, Valladolid-Universidad was built in the 1990s, mostly to facilitate students coming from the city of Palencia to the University of Valladolid (158).

The trip from Madrid to Valladolid is 161 km and takes 53 to 60 minutes on HSR and two hours 50 minutes on conventional trains. This HSR line began operations on December 22, 2007 and became a key element in the development of the railway network in the north and northwest of Spain (159). The line represents the first section of the North and Northwest HSR corridors, which were built later, and is now connected to other lines that continue to Palencia and Leon. This railway infrastructure is used by the rail services between Madrid and the autonomous regions of Castillla y Leon, Galicia, Asturias, Cantabria and the Basque Country (159). The line was built with standard gauge (1435 mm), as is common for HSR lines in Spain.

The corridor is served by the Madrid-Segovia-Valladolid, Valladolid-Burgos-Vitoria and Valladolid-Palencia-León-Asturias lines . The second and third lines begin in Valladolid with the line towards Palencia opening on September 29, 2015. At the time of this writing, the Valladolid-Burgos-Vitoria line was still under construction. This line will provide a connection between the provinces in the northwest and the northeast of Spain (160). This connection begins right before Palencia on the Valladolid-Palencia corridor and extends to Burgos and Vitoria, but it does not go through Valladolid. However, the line will reduce the travel time and avoid the need to pass through Madrid when traveling between these cities.

Impacts of HSR

As can be seen in Figure 24, the total population in Valladolid has somewhat decreased over the last 25 years. It witnessed a small increase in 2007, when Valladolid was first connected to Madrid via HSR, but started a slow and continuous decline after 2009 (161). Arguably, this has to do with the severe economic hardship that Spain started experiencing in 2009, rather than with any particular effects of the HSR. It is interesting to note that the foreign population started to increase after 2001 and kept growing until 2009, when it also started to decline.This may be related to the expectations foreigners had for employment in the region, perhaps due to construction of the HSR line but also (and most likely mainly) due to the real estate boom that Valladolid was experiencing prior to the financial crisis, and the associated demand for housing and other construction projects (162).

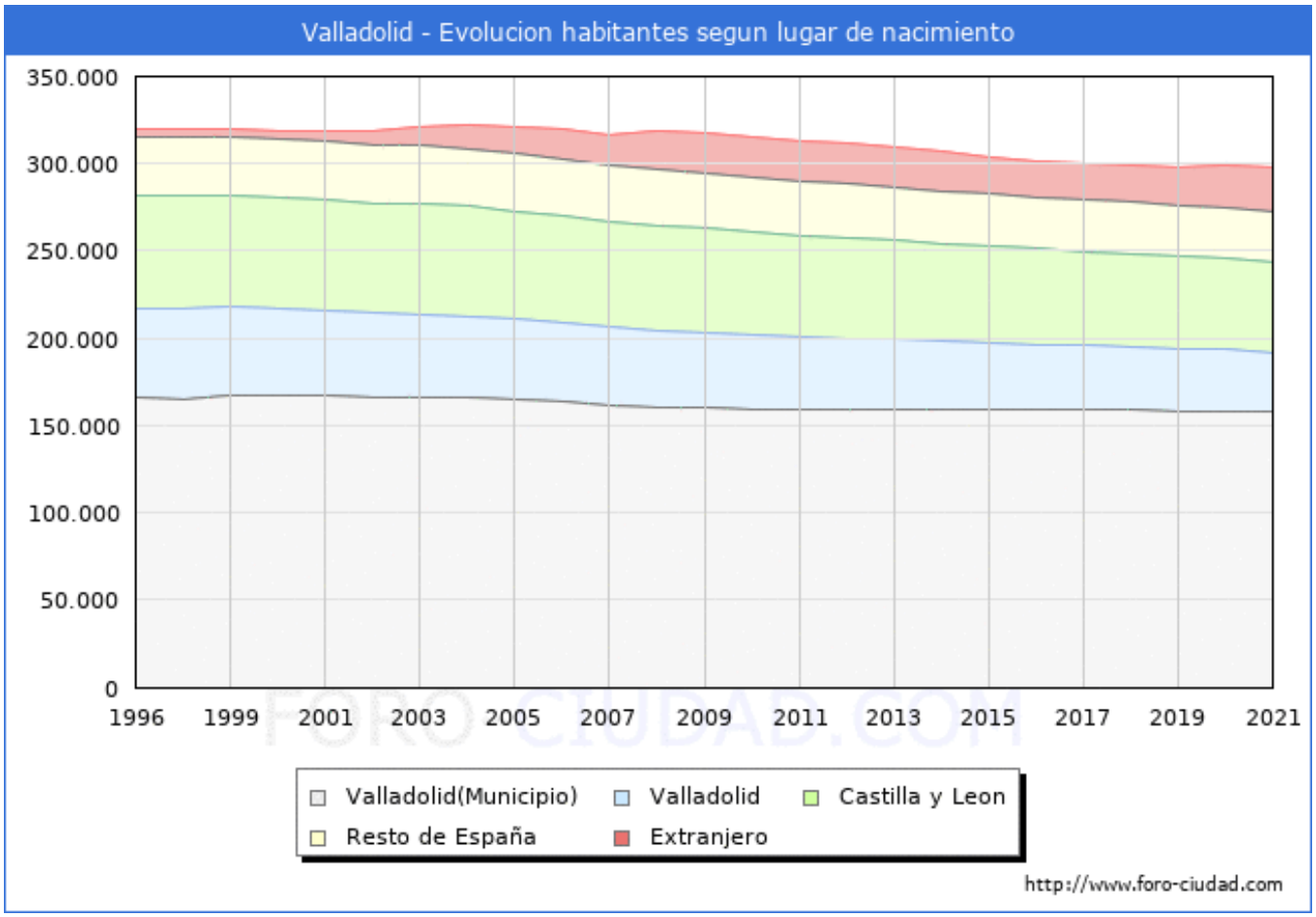

Figure 24. Evolution of Valladolid's inhabitants by place of birth.

Source: (Foro-Ciudad, 2022)

In terms of population density in different areas of the city, Figure 25 shows a higher density area around the east and southeast of the Valladolid Campo Grande Station, where the HSR trains arrive. This area also corresponds to lower-income areas in the city, which relates to the barrier effect generated by the train tracks, as discussed below. These population and density patterns, however, existed prior to the arrival of the HSR.

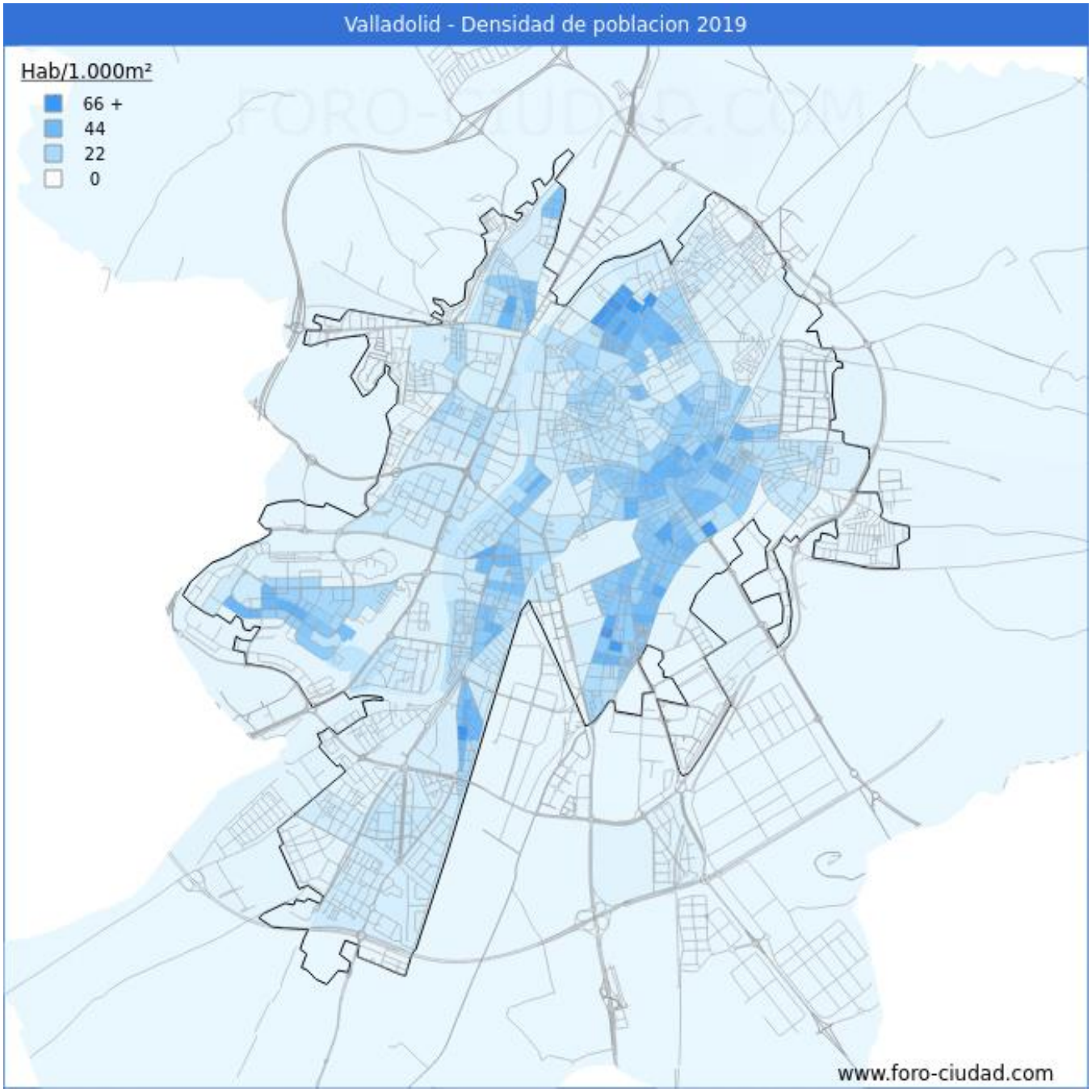

Figure 25. Valladolid population density.

Source: (Foro-Ciudad, 2022)

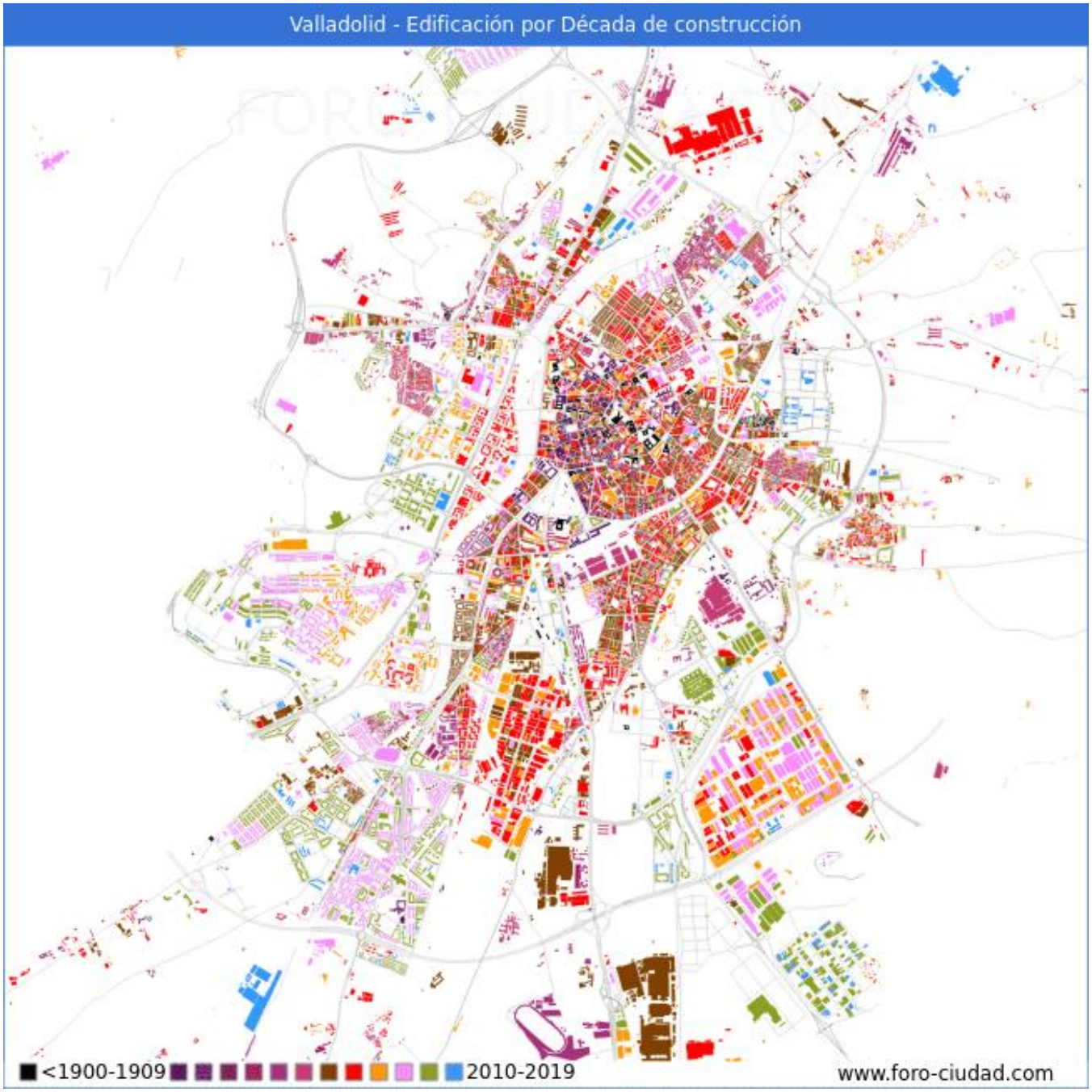

Figure 26. Buildings by decade of construction, Valladolid 2010-2019.

Source: (Foro-Ciudad, 2022)

Figure 26 shows how the city has evolved over the years, showing the buildings built in each decade. The most recent buildings, built between 2010 and 2019, are shown in blue. The buildings in green, built from 2000 to 2009, were constructed during the time when the HSR line was also being built, while the pink buildings

correspond to those built between 1990 and 1999. Because of the recession that started in 2009, there are fewer blue buildings than green or pink buildings.

It is, indeed, important to mention that some of the social and physical impacts from the presence of the railway infrastructure had already been present in the city before HSR service began, given that the city had railway tracks since 1864. Various sources in the literature report how the railway tracks created a "scar" in the city and divided it so that neighborhoods to the west of the tracks were more accessible and had better socioeconomic conditions than the neighborhoods to the east of the tracks (163) (164). The initial tracks were at grade, and to decrease the risk of accidents, an approximately two-meter (6.5 ft.) high wall was built to separate the tracks from the surrounding area, particularly in the central part of the city. Previous city plans and the initial Valladolid station plan considered burying the railway tracks to improve the area's accessibility and connectivity, eliminating or mitigating the barrier effect the tracks had created (163). Nonetheless, the most recent city plan, which considers burying the tracks, the so-called Rogers' Plan (General Urban and Historic Center Plan (PECH) on the Central Rail Network),[2] has not been implemented as it would be extremely costly (164) (165).

However, residents complain about safety issues, both in terms of personal safety and accidents that occur. The underground pedestrian crossings are known for the assaults and robberies that have happened there, and there have also been some deadly crashes involving pedestrians seeking to cross the tracks (163). The initial HSR connection project included plans to improve access to the Valladolid Campo Grande Station, similar to what was done in Zaragoza (164). The city created a contest to redesign the station and the neighboring station area. The winning proposal aimed to improve accessibility to the station by burying the parking lot and creating a greener and more walkable environment in front of the station, as well as providing connecting paths through a commercial area over the tracks. However, the design was never fully implemented because of the national economic crisis that intervened and the anticipated costs both for purchasing land and for construction (164) (166). To minimize the problems this has caused, the city has planned different actions to improve the permeability and accessibility from the affected neighborhoods to the city center (167).

Construction of the HSR corridor through Valladolid also entailed installing certain viaducts and tunnels that the rail operator Renfe demanded to provide a direct route to the city. These include the San Pedro tunnels (two parallel tunnels 8.93 km each), the Guadarrama tunnel (28.4 km), and the Arroyo viaduct, which is the longest continuous decked viaduct in Europe. The Arroyo viaduct passes through an area of environmental importance for Spain, and allows for the passage of animals to reduce adverse impacts on the environment. However, this infrastructure work consumed most of the corridor's budget, which prevented the implementation of the Roger's station plan (159).

HSR service along the corridors of Madrid-Valladolid and Madrid-Zaragoza has witnessed a change in the type of travelers who use it, mainly gaining mid-distance travelers who previously used conventional trains or

[2] The name of the plan in Spanish is "PLAN GENERAL DE ORDENACIÓN URBANA Y DEL PECH DE VALLADOLID EN LA RED FERROVIARIA CENTRAL (PLAN ROGERS)."

private cars for their trips. This suggests that the metropolitan area has become more integrated and now extends 250-300 km (155-185 mi.) or 60-80 min by HSR from Madrid. Not only has HSR attracted travelers from other travel modes, but this integration has also helped attract new riders, medium-distance travelers who now use the service to commute for work or study purposes, increasing the areas from which workers used to come from, and extending the geographic boundaries of the labor market (168).

Another economic impact discussed in the literature is that the value of station-adjacent land has increased with the launch of HSR services. This was the case especially on the west side of the tracks in Valladolid, as this area is also closer to the downtown and historic center. The higher values could be related to the greater accessibility these neighborhoods now have to the center of Valladolid and the HSR station. This, however, has not been the case for the east side of the tracks, where about 100,000 residents live, and which has been historically less accessible and physically segregated from downtown because of the railway tracks (163). This translates into longer walking distances to the downtown area since the tracks can only be crossed where pedestrian tunnels are located. Residents living on the east side who drive a car also need to use the tunnels to pass under the railway tracks and reach downtown (Figure 27 and Figure 28).

Figure 27. Pedestrian tunnel in Valladolid.

Source: Elnortedecastilla.es

Figure 28. Car tunnel in Valladolid.

Source: eldiadevalladolid.com

In terms of employment, some citizen groups have opposed HSR services, claiming that such services favor large cities, attract skilled workers from smaller towns, and are slowly converting these smaller towns into suburbs or dormitory towns (169). They specifically note that the Valladolid-to-Madrid service targets high-skilled white-collar jobs that employ technocratic, urban nomad, and cosmopolitan people working in multinational companies, banks and other private businesses (169). In Valladolid, this has meant a decrease in agriculture and industry jobs (probably both unrelated to the launch of HSR services) with only a small increase in service jobs since 2008, when the HSR services began. Figure 29 shows high volatility in service sector employment. Factors external to HSR, such as Spain's economic downturn, and later the COVID-19 pandemic, had much to do with the reduction of service jobs during certain periods. Additionally, there are now fewer people working locally in Valladolid (Figure 29 - Figure 31) (170).

Figure 29. Valladolid residents employed in the service sector (thousands), 2008-2019.

Source: (Instituto Nacional de Estadistica, 2022)

Figure 30. Valladolid residents employed in the industrial sector (thousands), 2008-2019.

Source: (Instituto Nacional de Estadistica, 2022)

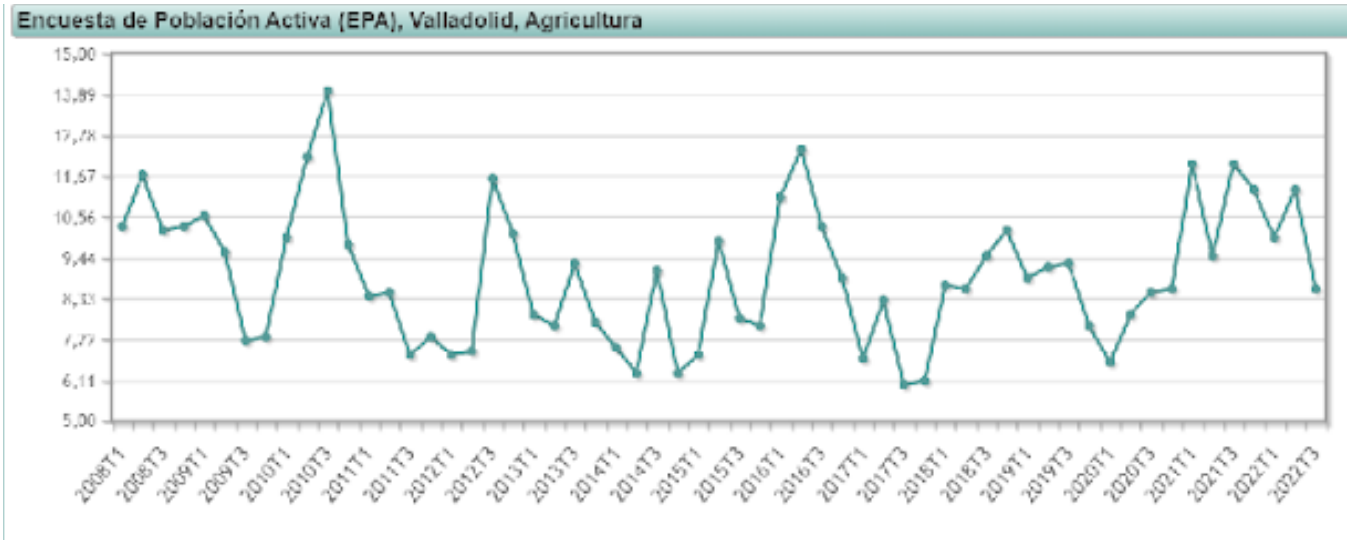

Figure 31. Valladolid residents employed in the agricultural sector (thousands).

Source: (Instituto Nacional de Estadistica, 2022)

Valladolid experienced lower unemployment rates right before HSR service began (2006-2007) and during its first years of operation (2007-2008), possibly because of the construction jobs related to the development of the HSR corridor. Soria Cáceres (2010) mentions that some of the jobs created were associated with manufacturing the trains, which took place in the manufacturing plants in Malaga and Valladolid (165). These plants were also going to be converted to maintain and repair the AVE (Alta Velocidad Espanola) trains (165).

The economic crisis that started in 2009 brought high levels of unemployment to the region, which peaked in 2014. Further, unemployment was lower in 2015 and 2016, not because of more local opportunities for employment, but because many young workers left the province for other parts of Spain and Europe in search of better employment opportunities (171).

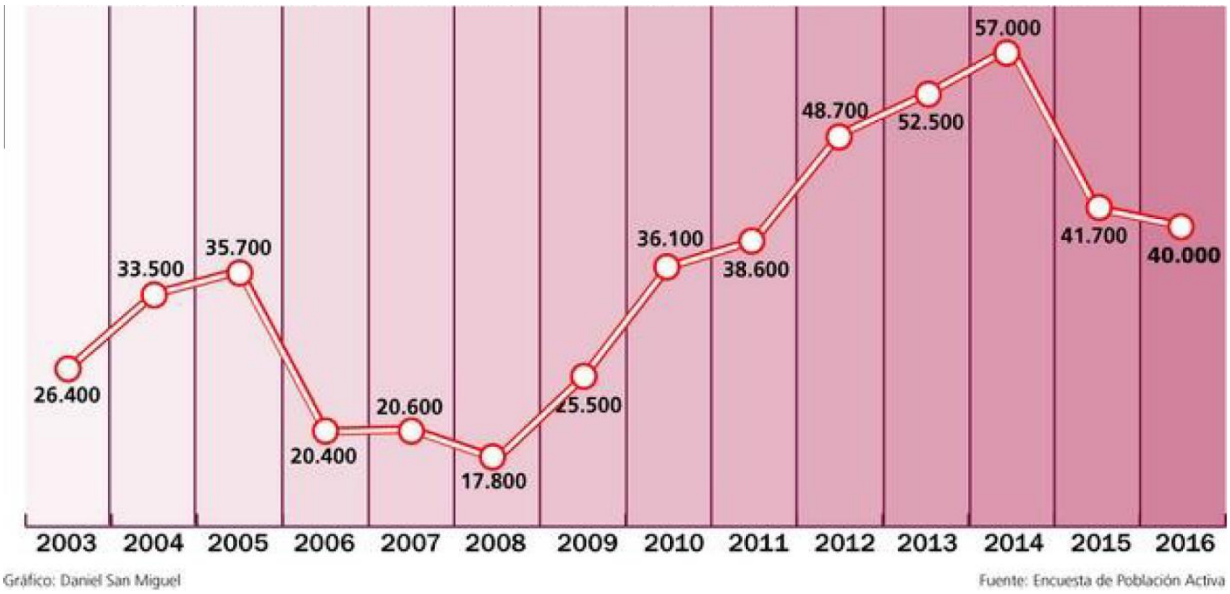

Figure 32. Number of unemployed people per year in Valladolid, 2003-2014.

Source: (Fraile, 2016)

Relevance for California

The need to construct costly long tunnels and viaducts in the Madrid-Segovia-Valladolid corridor to reduce the surface impact of the tracks and protect the natural environment and wildlife, considerably increased the cost of the project. Similarly, California's Central Valley also has a delicate natural environment that may be affected by the California HSR Program. It is important to consider how to protect this environment and what infrastructure will be required to minimize the negative impacts.

In Valladolid, the HSR line posed a barrier to the movement of people and the connectivity of the community; though to some degree the barrier effect was already there due to the historical presence of conventional railway tracks. The Valladolid station was historically near the old city, now the city center, and the city grew around it. However, the enhanced accessibility to services in this area and the station made the land between the train station and the center more attractive for development than the land on the other side of the tracks. This attractiveness and enhanced accessibility are more common for stations which are well-connected to downtown areas.

The barrier originally created by the rail tracks was further exacerbated by the new HSR infrastructure, making the tracks more dangerous to cross and the physical barriers created by them more severe. This barrier effect varies for the different neighborhoods adjacent to the station, causing a greater disconnect to the side of the city that is the furthest from the downtown area. Though there are underground pedestrian crossings, these are considered unsafe, particularly at night. Given that the city was unable to put the tracks underground due to financial reasons, Valladolid has instead sought to construct and maintain the pedestrian crossings. The frequency, design, and maintenance of these crossings is very important to make pedestrians feel safe. In

California, different urban treatments should be considered to minimize any barrier effects, particularly if the tracks impede access to the city center and services for certain areas.

Finally, in terms of employment, once in operation HSR service in Valladolid facilitated the connection to the large job market in the Madrid metro area, which favored skilled workers who could better access those types of jobs, and increased opportunities for some people to live in Valladolid and work in Madrid. This has benefited those with the qualifications and the types of jobs that allow this flexibility. Construction jobs saw an initial boost, as expected, as the HSR line was being built, but they declined significantly during the Spanish economic crisis, ust after the HSR trains began operating, and many projects were not developed as planned. This case is a clear example of how external factors may impact a project in unpredicted ways.

Zaragoza

City Description

Zaragoza is the capital city of the autonomous community of Aragón and the fifth most populated city in Spain with 675,301 residents (172). It is located 330 km from Madrid, 300 km from Barcelona, and approximately 300 km from Bilbao and Valencia. Thus, it is considered an intermediate city, both in terms of size and location, as it is right on the corridor that connects the two major cities in Spain. The city is also a traditional crossing point for road and rail networks, as it can be seen in the map in Figure 12 (173).

High-Speed Rail Service and Stations

The first railway that passed through Aragón was inaugurated in 1861 and connected Zaragoza with Lleida (or Leida in Catalan) (Historia de Aragon, 2021). Within a short period of time, Zaragoza became a railway hub connected to the cities of Pamplona, Madrid, Lleida and Barcelona in 1863 (174). Starting in the 1930s, railway construction slowed down for several decades as most funding went towards the construction of the road network (174).

The first railway station in Zaragoza, the Northern Station (Estacion del Norte) was inaugurated in 1861 at the northern side of the old town and remained in operation until the 1980s (175). Shortly after, the current conventional rail station opened in 1863 on the Zaragoza-Madrid line and was initially named Santo Sepulcro Station (now Zaragoza-Portillo). These stations are approximately 3 km (1.9 mi.) apart and both approximately 1.5 km (0.9 mi.) from the old town central plaza, the Northern Station to the north and Santo Sepulcro to the west (Google Maps, 2023). For decades, both stations operated simultaneously with services to different destinations and were later connected by a railway bridge (175). Then, Santo Sepulcro Station was expanded in 1896, and in 1967, became the main station for travelers going to and from Zaragoza and other cities. In 1973, the owner Renfe expanded and made additional modifications to the station building and changed its name to Zaragoza-Portillo (176).

Partly because of the improvements to the Portillo station and because of the impact Renfe has had on smaller private train companies, the old Northern Station started losing importance in comparison to the Zaragoza-Portillo station. By 1973, no passengers arrived from or traveled to the old Northern Station, and it was only

used for freight transportation. Eventually, transportation services completely stopped at this station, which became a local civic center, and its railway tracks were removed (175). On the other hand, Zaragoza's Portillo station continues to operate but only for suburban metropolitan rail services.

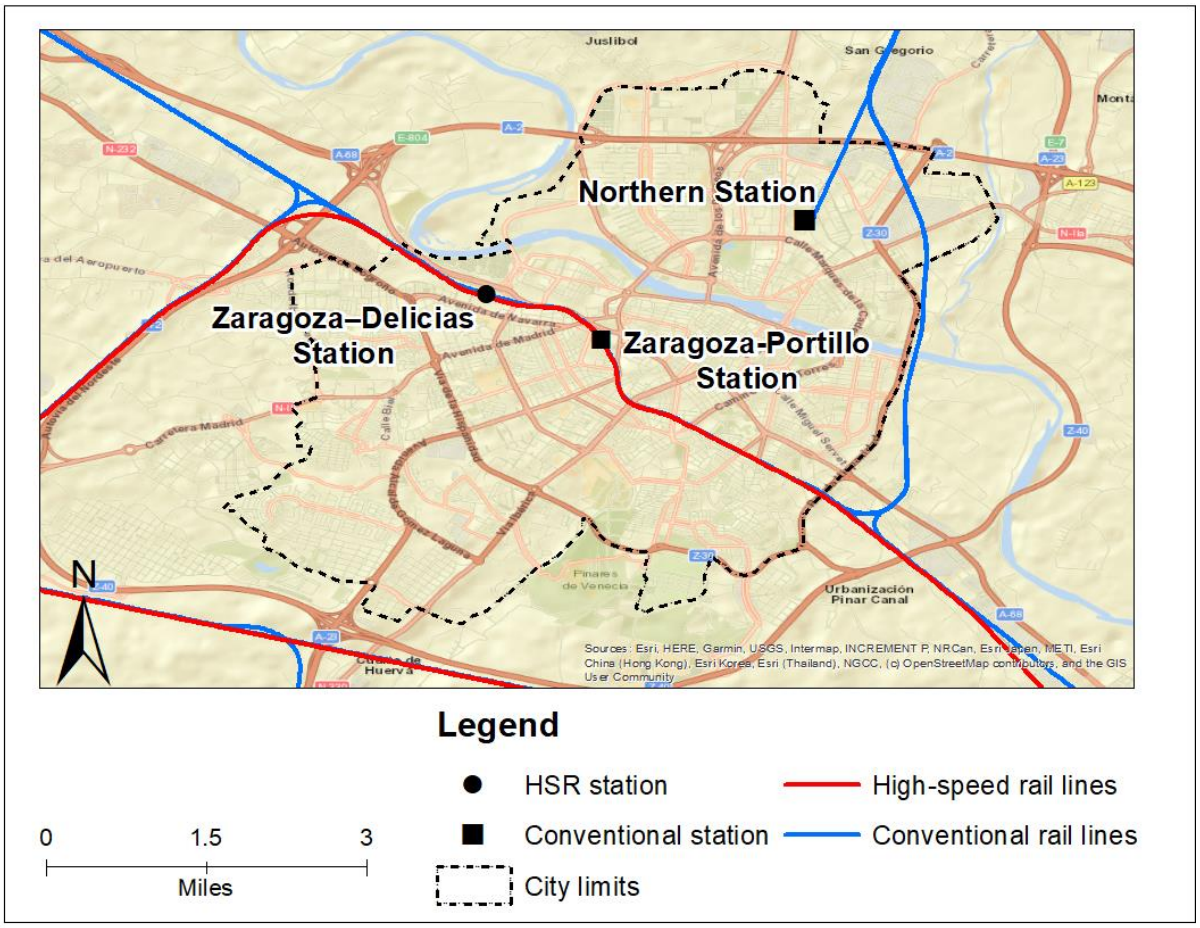

Figure 33. Railway stations in Zaragoza.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021) OpenData Esri España (2023), Red de ferrocarriles de España.

Note: HSR lines in operation are represented in red; conventional lines in blue.

The Zaragoza-Delicias HSR Station opened to the public in 2003. It was located in a development area on the northwestern side of the city, just south of the river. This location allowed a larger area for the station, while still being in proximity to main interregional roads. The objectives of choosing this location for the station were to have the space for an intermodal bus and rail station, serve the western neighborhoods of Zaragoza, bring new services to this area, and line the river with walkable paths and green areas as part of the development plan for the west part of the city (168). Additionally, by transferring services from Portillo to Delicias, the city

wanted to promote an urban renovation in the center of the city and eliminate the scar that the railway had caused (168).

The station is an intermodal terminal, as it also hosts an intercity bus station and a hub for regional transportation and HSR services that connect Madrid and Barcelona to France (177). It can be reached by bus, car, taxi, walking or biking. However, given that the station is located at some distance from the city center, it takes around 40 minutes to reach the station on foot from there, 15 minutes by bike, between 16 and 40 minutes by bus (depending on the route), and 10 to 30 minutes by car. Since the station's inauguration, more than three million people have been using the station annually, making it the fourth largest HSR station in Spain, after Madrid, Barcelona, and Sevilla (177).

The station was designed by architects Carlos Ferrater and José María Valero and was developed by the construction company Ferrovial. The main building is more than 600 meters (1968 ft.) long and 180 meters (590 ft.) wide, and the entire area occupied by the station is nearly 19 hectares. The station has 10 railway tracks (five with standard gauge (1435 mm) and five with Iberic gauge (1668 mm)), and each one has boarding platforms that are 400 meters (1313 ft.) long. The Delicias station has been considered an icon of urban transformation for Zaragoza, given its size and the developments built around it (177).

The Zaragoza-Delicias Station opens daily from 05:30 a.m. to 12:00 p.m. At the time of this writing, the station has a total of 99 scheduled trains daily, including 26 AV (HSR) to Madrid, 28 AV (HSR) to Barcelona, and the remainder to Seville, Valencia, Miraflores, and other cities, and including both high-speed and conventional regional trains (179). The travel time from Zaragoza to Madrid or Barcelona by HSR is approximately one hour 20 minutes (173).

Impacts of HSR

As Figure 34 shows, the city of Zaragoza saw a significant expansion of its population in the 20th century. Since the opening of HSR services in 2003, the population continued to increase and reached a maximum of 682,006 residents in 2013. Currently, the population in Zaragoza is experiencing a slight decline compared to the first decade of the 21st century. However, the population of the entire metropolitan region continues to grow.

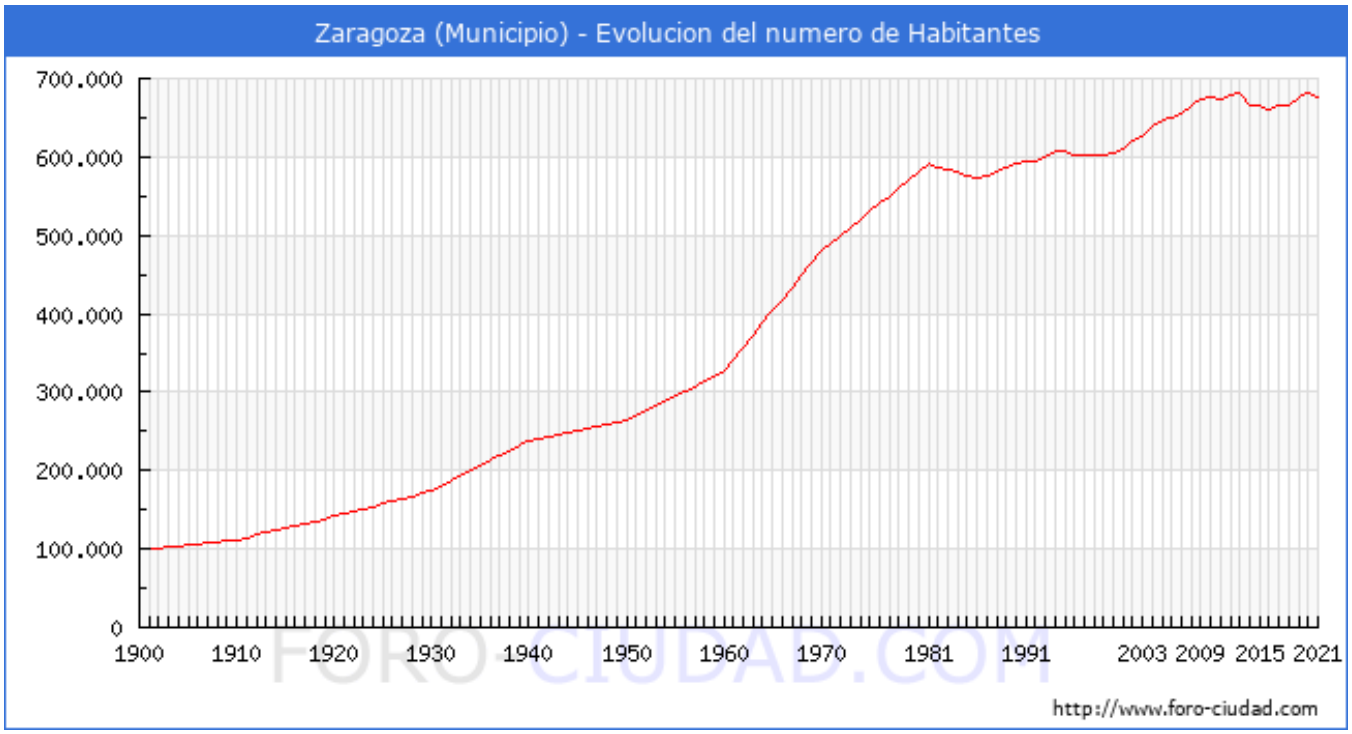

Figure 34. Population growth in Zaragoza, 1900-2021.

Source: (Foro Ciudad, 2022)

Zaragoza experienced an increase in foreign residents (*Extranjeros*) from 2003 (when HSR service started) until 2013, as well as a steady but small rise in the population of residents born in the city of Zaragoza, but not in the outlying region.

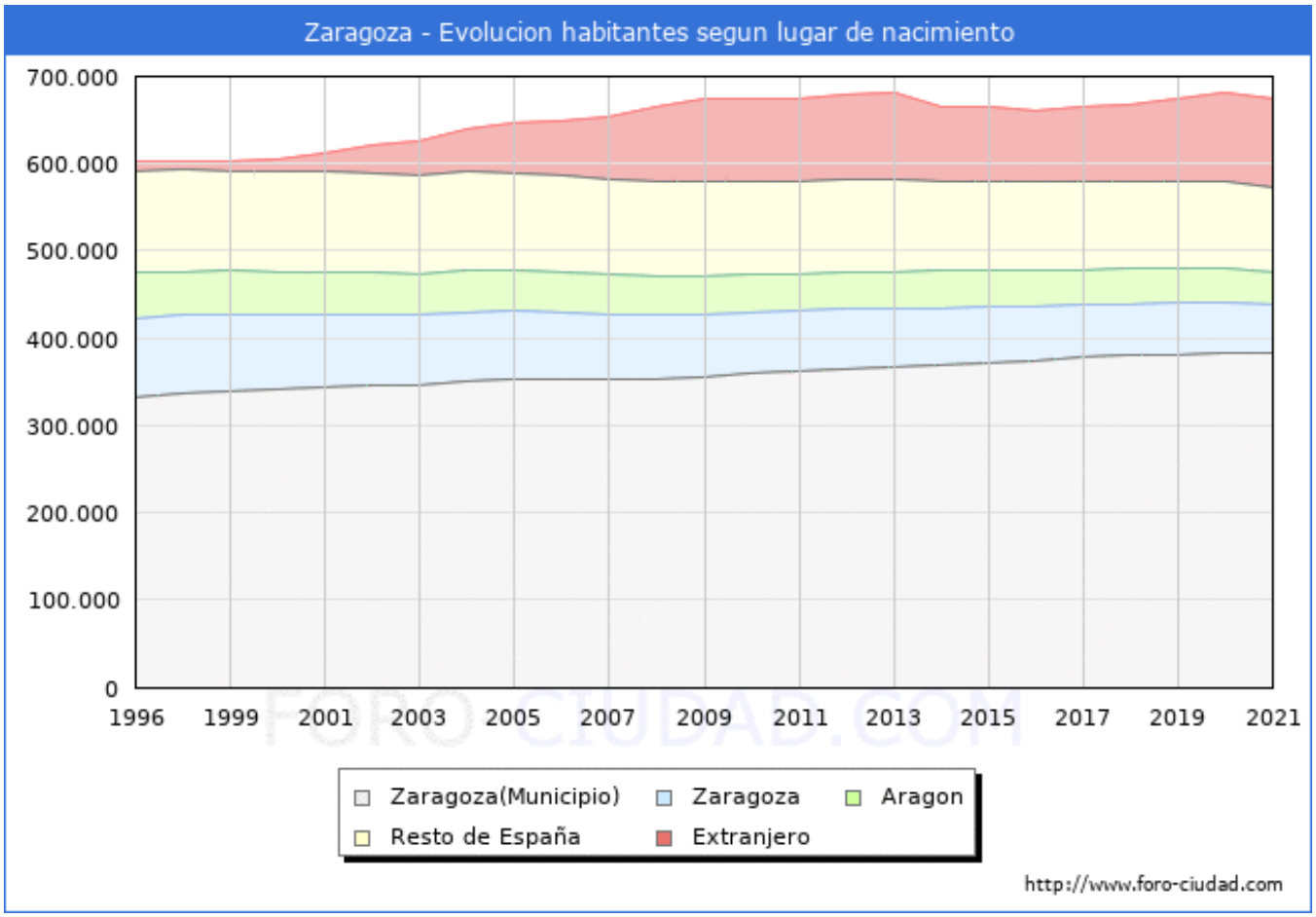

Figure 35. Evolution of population in Zaragoza, according to place of birth.

Source: (Foro Ciudad, 2022)

As HSR became the primary mode of transportation between Barcelona and Zaragoza and between Zaragoza and Madrid (Román, Espino, & Martín, 2008), Zaragoza also witnessed an increase in national and international visitors, especially for conferences and other events (173). Further, Expo Zaragoza 2008 took place a few years after the inauguration of the Zaragoza-Delicias Station and helped to attract further attention to the city and boost tourism.

A significant impact of the arrival of HSR to Zaragoza has been the redevelopment of the area around the city's HSR station. The city took advantage of the infrastructure development required for HSR to design not only a new station but also to re-envision the area surrounding the station (179). The city created a plan for this area, which included new large-scale buildings that became emblematic landmarks, such as the Centro de Especialidades Médicas Inocencio Jiménez Delicias (Medical Specialty Center, with advanced services in several areas of medicine, including pneumology, orthopedic surgery, and neurology) and the Augusta shopping mall (163).

The city hosted the World Exhibition in 2008, also creating a new Industrial-Logistic Park and a new industrial area for recycling. These infrastructural projects brought significant physical changes to the city of Zaragoza. The transformation included building an additional road bridge and a new rail bridge over the Ebro River, for a total of three road and two rail bridges.

These new city attractions and opportunities were reflected in an increase of real estate transactions in the city, as shown in Figure 36. These reached a peak in the years after the HSR station was opened, but dropped considerably in the years following the Spanish economic crisis of 2009. However, there is no evidence in the literature about the extent to which land values have increased or gentrification has followed as a result of the inauguration of HSR service.

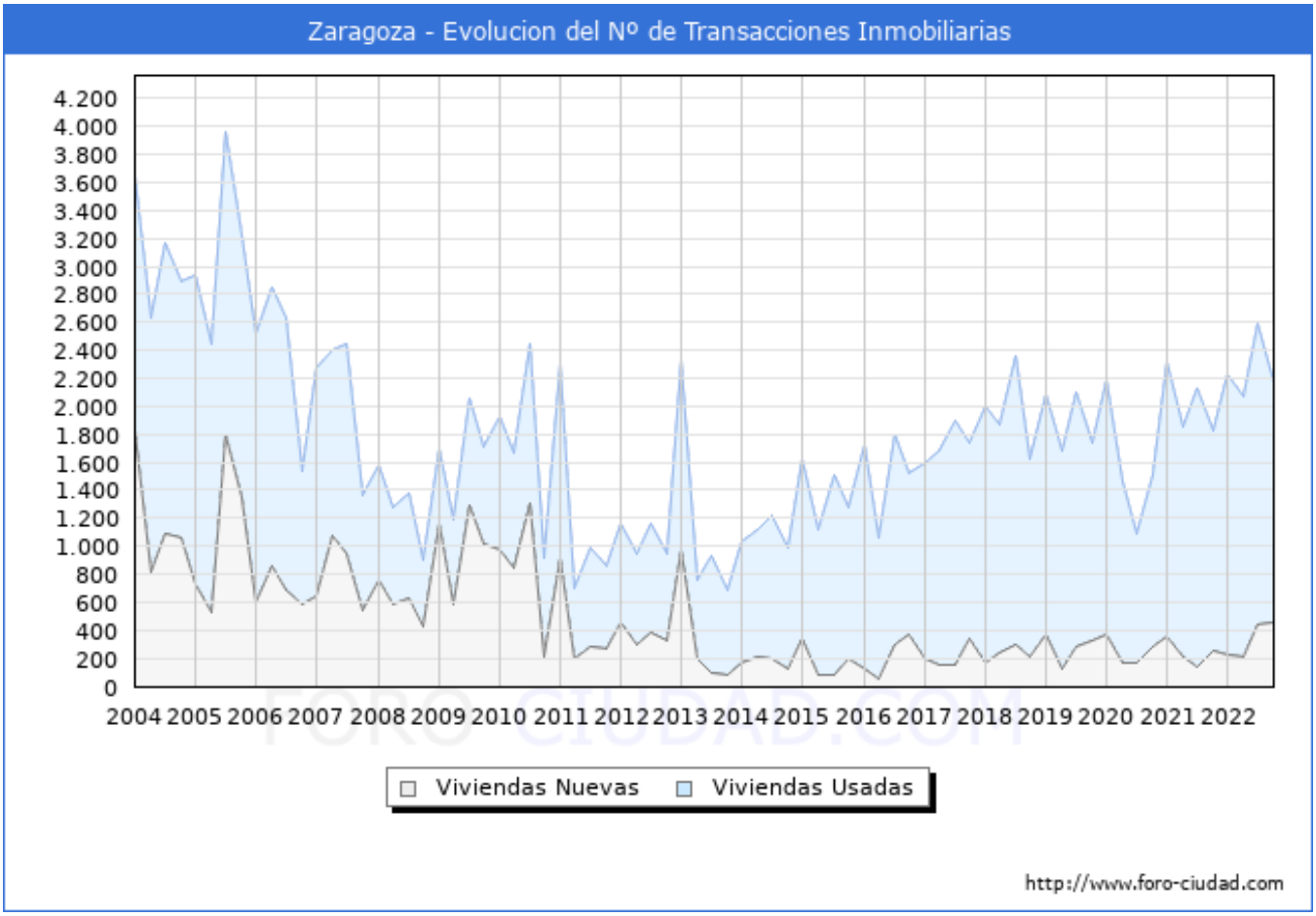

Figure 36. Numbers of real estate transactions, Zaragoza, 2004-2022.

Source: (Foro Ciudad, 2022)

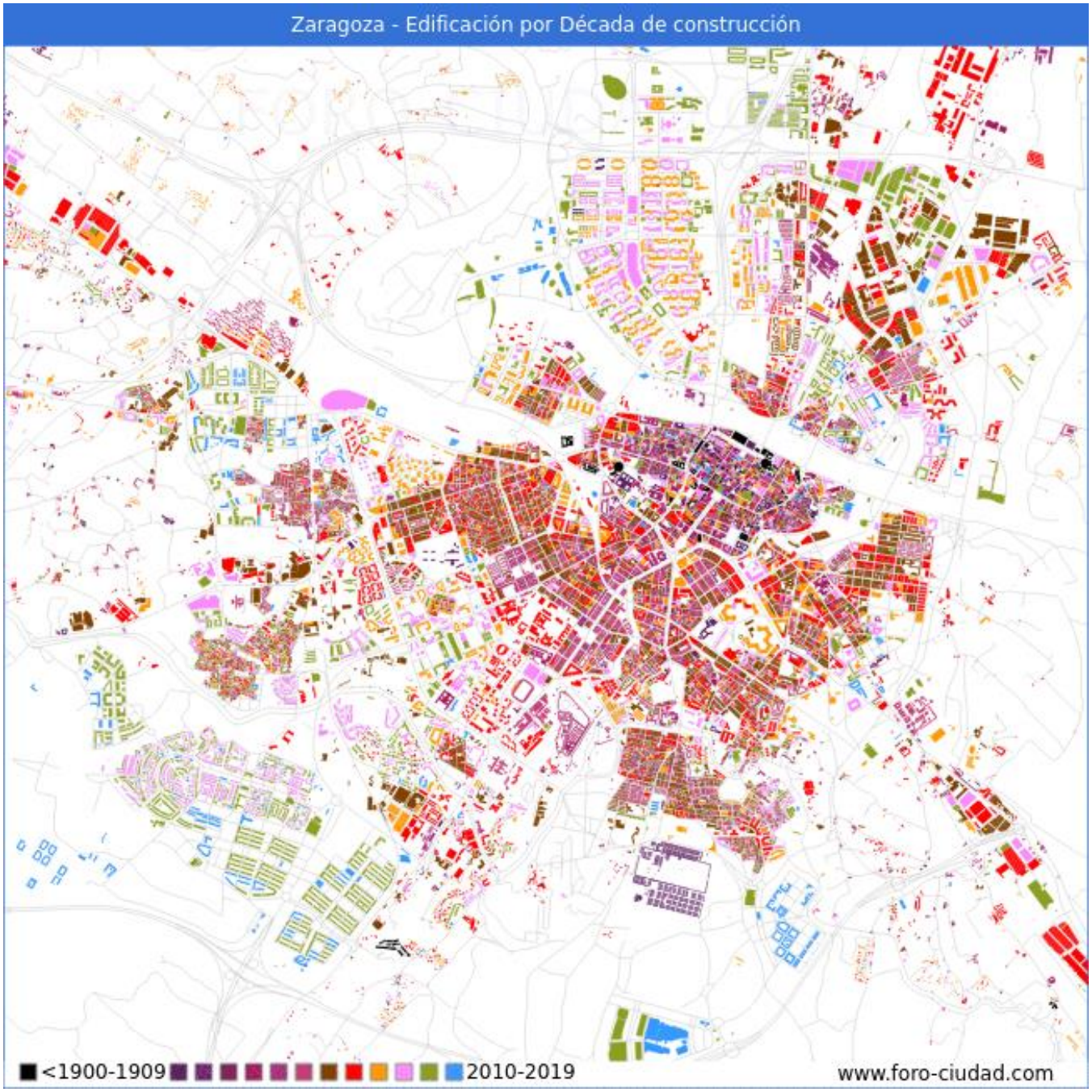

Figure 37. Buildings in Zaragoza by decade of construction.

Source: (Foro Ciudad, 2022)

Given the strategic location of Zaragoza between Madrid and Barcelona and the city's rather extensive area, there is abundant space for a variety of land uses, and the city is also attractive for industry. Indeed, several automotive companies and related manufacturing industries have located in Zaragoza and play an important

role in the economy of the city and the region. Zaragoza's metropolitan region is home to an Opel factory, located at the west of the city. Recently, logistics and information and communication technology (ICT) activities have also been attracted to Zaragoza (179) (180) thanks in part to the city's urban marketing and the transformation of the city's image for both internal and external audiences, taking advantage of the World Expo but also the coming of HSR to the city (179).

This urban marketing was part of a strategic planning process that Zaragoza began in the early 1990s when the city issued its "Ebropolis" Strategic Plan, which was approved in 1998 and included goals for the city and surrounding areas. The implementation of this plan coincided with the General Urban Territorial Plan, approved in 2001, which included the HSR project (179). This helped keep urban planning and transportation objectives aligned, making the area around the station in effect a transit-oriented development. Additionally, hosting the International Exposition in 2008 also helped the city to position itself internationally and attract people from around the world (179). Nevertheless, some of the buildings that were planned around the station were not developed because of the 2009 economic crisis.

Relevance for California

The Zaragoza example shows that HSR station-areas that have the benefit of a well-developed and articulated urban plan can promote and accelerate development around them. Each of Zaragoza's stations promoted some type of development. Development around Zaragoza's first two stations was more spontaneous, and primarily residential, while the remodeling and expansion of the Delicias HSR station was carefully planned and integrated with the strategic plan of the city, promoting a variety of land uses around it. Thus, strategic land use planning around the station has the potential to attract more development in station-adjacent areas and increase the economic activity of a city.

The Delicias HSR station was not located in the city center but rather in an area that had potential for urban development. This can also happen in some California station-cities that build HSR stations in more peripheral city areas. In such cases, connecting the station to other parts of the city, as well as other cities on the HSR network is very important. Zaragoza has witnessed continuous and increasing demand for its HSR services, as it provides a link to the region of Aragon, which is well connected with other regional services by train and bus. The Delicias HSR station's intermodal characteristics have also contributed to making this station a successful transportation hub. At the same time, Zaragoza has particularly benefited from its location on the most important transportation corridor of the country, almost equidistant from Madrid and Barcelona.

Summary of Impacts in Spain

Table 6 presents a summary of the HSR impacts on each of the case study cities in Spain.

Table 6. Summary of HSR impacts on Spanish station cities.

Case Study	Economic Impact	Physical Impact	Environmental Impact	Social Impact	Policy Impact
Galicia corridor	There was a slight land value increase in the couple of years after HSR inauguration (54).	A slight increase in new buildings along the road that leads to Santiago's station at the city's southeast was observed (54).		Slight population growth in Santiago (54)	
Valladolid	Land value for properties adjacent to the station increased (48). Construction jobs increased due to HSR development, with lower unemployment rates between 2006 and 2008 (57).	The tracks created a barrier effect separating the neighborhoods in the city (48). The presence of the tracks caused reduced accessibility for residents on the other side of the station/tracks (48). HSR has led to stronger metropolitan integration of Valladolid as a dormitory city connected to Madrid (56).	The HSR project experienced high costs for tunnel and viaduct infrastructure to mitigate environmental impacts of the corridor (50). The launch of HSR services led to a substantial shift from cars and conventional long-distance rail to HSR services (56).	Population grew in Valladolid at first, followed by a slight decrease which can be largely explained by Spain's economic crisis (55). HSR travelers tend to be higher-income, high-skilled workers (56) (51).	Local governments coordinated the development of a plan to redevelop the area around the station (50).

Case Study	Economic Impact	Physical Impact	Environmental Impact	Social Impact	Policy Impact
Zaragoza	HSR led to an increase in the number of visitors and tourists (52).	The HSR program led to the re-envisioning and redevelopment of the area surrounding the Delicias Station (17).	The opening of HSR led to a substantial shift from cars, conventional long-distance rail and air travel to HSR services (59).	The local population grew, including an influx of foreign-born residents (58).	There was a strong coordination of urban planning and transportation policy in the vision of the city-station (17).
	An increase in real estate transactions was recorded in the years after HSR inauguration (58). Logistics and Information and communication technology (ICT) activities have been attracted to Zaragoza (17).	Developments included large-scale flagship buildings and the Augusta Mall (48).			The planning of the HSR station and services was coordinated with urban marketing, a new city vision and the organization of Expo 2008 (17).

Italy

In Italy, the HSR network consists of 1467 km (912 mi.) (Figure 38). The country's first HSR corridor was inaugurated in 1977 connecting Rome to Florence, but the HSR network started proper operations only after additional segments were added to it in the early 2000s with the Turin-Milan-Bologna-Florence-Rome-Naples-Salerno main HSR corridor.

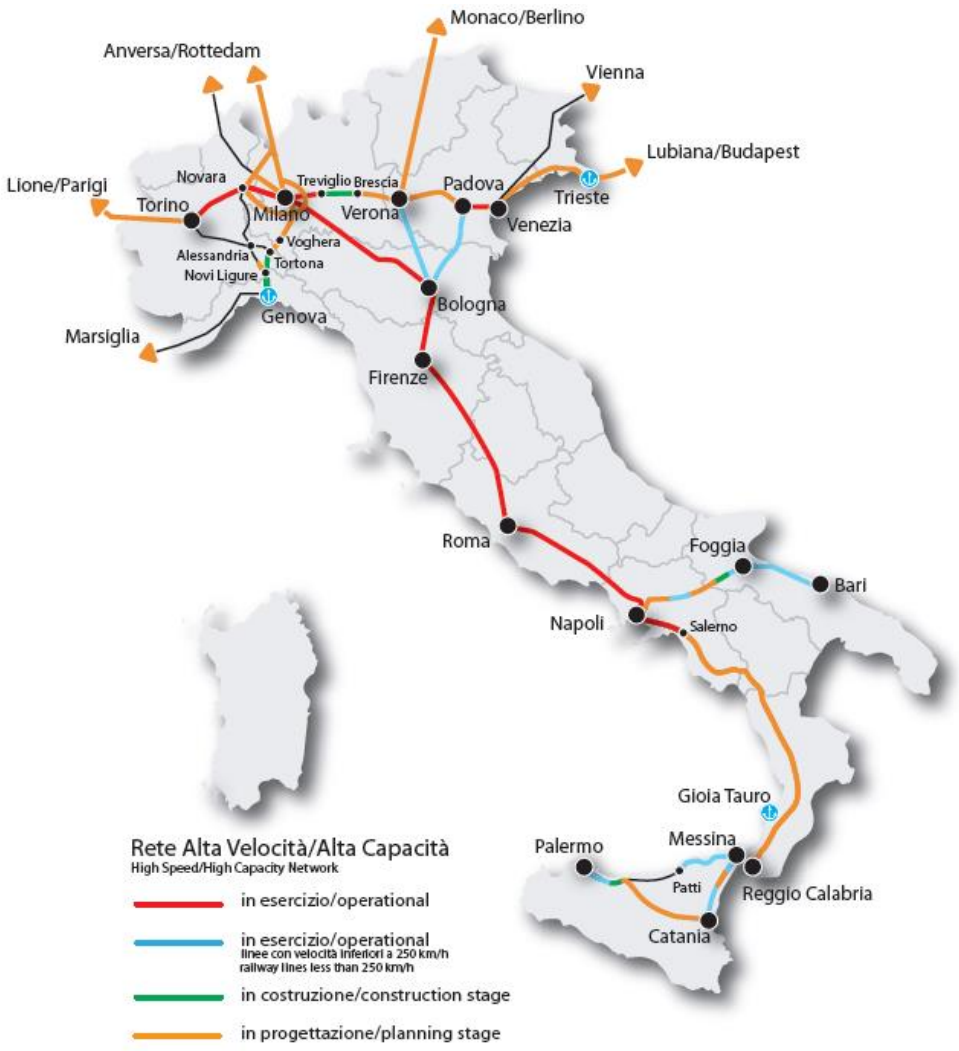

Figure 38. Italy's HSR network.

Source: Desmaris , C. and Corccolo, F. (2018). *The HSR Competition in Italy: how are the regulatory design and practices concerned? Research in Transportation Economics, 69, pp.290-299.*

Reggio Emilia

City Description

Reggio nell'Emilia, also known as Reggio Emilia, is a medium-size city (and seat of the province carrying the same name) in the Emilia-Romagna region in Northern Italy. The city is located in the valley created by the Po River (the Padan Plain, or *Pianura Padana*) between Bologna and Milano, which are approximately 61 km and 142 km distant, respectively. Reggio Emilia has 169,545 residents (181) and a population density of 1900 residents/square mi.

The region has seen massive economic development in the past few decades. After World War II, the entire Emilia-Romagna region switched from a predominantly agricultural economy to an industrial one. Reggio Emilia is presently known for both its agricultural and culinary heritage as well as its industries. For example, the well-known Officine Meccaniche Reggiane, which produced planes since before the war and later focused on the production of rail and road vehicles, has been operating in Reggio Emilia for many decades. More recently, Reggio Emilia's economy has shifted towards the service sector. Although the largest number of local companies are in the construction sector, the second and third largest number of companies are respectively in commerce/retail and services (182).

High-Speed Rail Services and Station

Reggio Emilia's HSR station, Reggio Emilia AV Mediopadana (where AV stands, in Italian, for *alta velocitá*, or high-speed), is located on the Torino-Salerno line, the backbone of Italy's HSR system connecting Northern and Southern Italy, via Milan, Bologna, Florence, Rome and Naples (183). The station is more precisely located on the Milan-Bologna segment of the line, built in 2008, and constitutes the only stop in that strategic portion of the route (184).

In 2002, the city of Reggio Emilia contracted star architect Santiago Calatrava to develop a plan for a new access to the city from the north. The HSR station was part of this plan and is accessible via highway. Inaugurated in June 2013, the station was conceived as a major architectural project, including a landscaped "piazza," ample parking spaces, and a drop-off area in front of the station (185). It is located inside the Reggio Emilia city borders but in a low-density area at the city's periphery, about 4 km north of the historic center (186). Its name, "Mediopadana," refers to the station's central location in the middle of the Padan Plain (183). The Mediopadana area represents a dense urban network, gathering together the cities and portions of the provinces of Parma, Modena and Mantova (183).

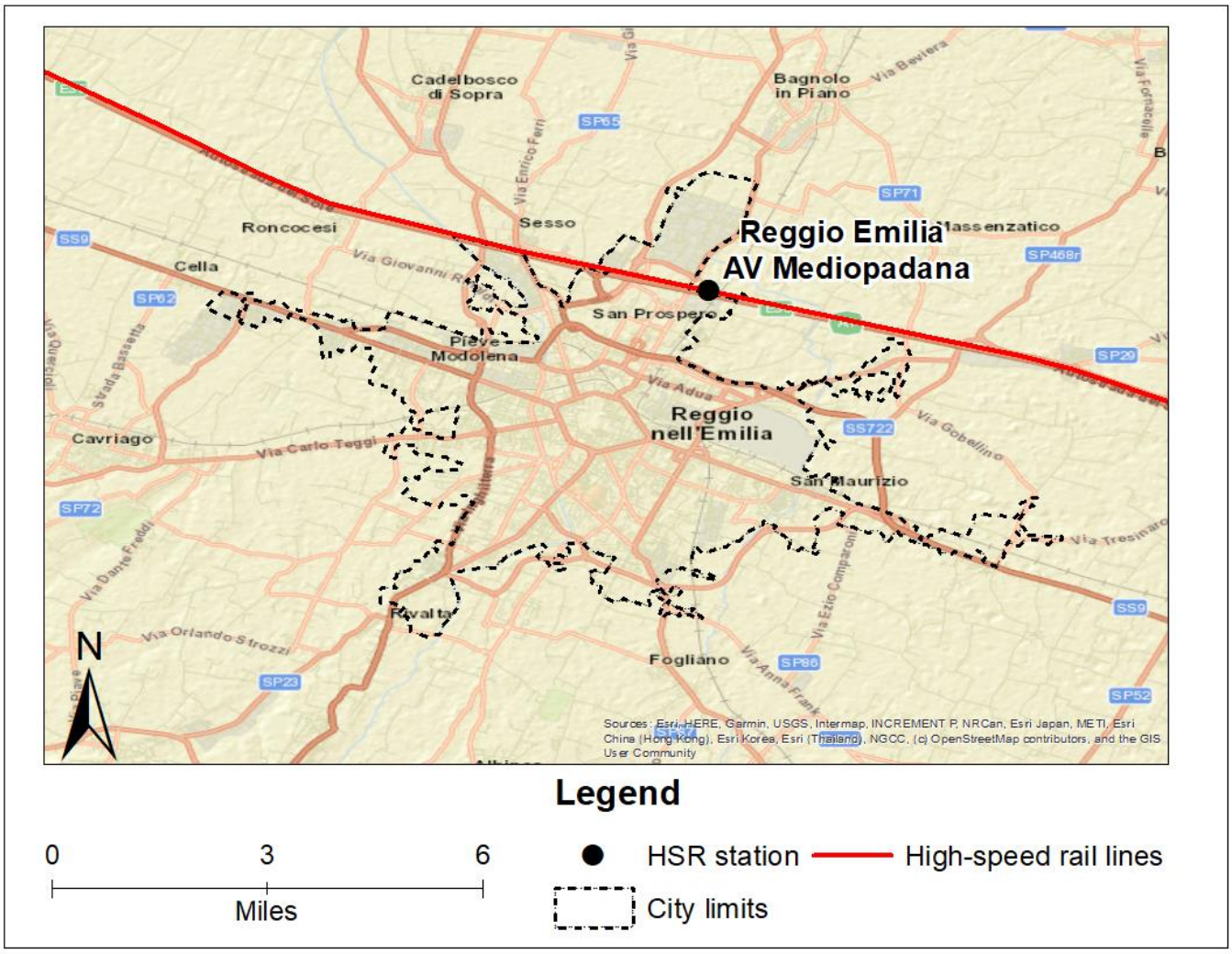

Figure 39. Reggio Emilia station location.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community (Esri, 2021)

The station was conceived by Calatrava as part of an infrastructure program to create a northern gateway to Reggio Emilia, through the addition of three new bridges and a toll freeway entry/exit station along with the new HSR station (186). The station's unique shape forms a dynamic wave of 483 meters through a repetition of modules made of 25 steel portals (185). This monumental design can be viewed from the parallel "Sun" freeway (*Autostrada del Sole*) and is meant to constitute a strong landmark for the city and the region, symbolizing its renaissance (183).

The station was planned to be easily accessible via car from the main freeway and other local roads so that individuals from the whole region are able to reach it easily. This demonstrates that the station was meant to serve a rather large catchment area, including the whole Mediopadana area instead of just the city of Reggio

Emilia (184). In fact, according to data from the railway infrastructure company that manages the station, 58 percent of the station's users come from a municipality other than Reggio Emilia (187). Accordingly, when in 2021 the mayor of neighboring Parma requested a high-speed rail station for his city, Reggio Emilia mayor Luca Vecchi responded that Mediopadana AV already serves Parma and other cities in the region (184). He noted how creating a new station in Parma or other cities in the region would diminish the number of passengers using the Mediopadana AV station.

Mediopadana AV has been served by a growing number of trains since its opening. While 12 trains stopped by the station daily when the station was inaugurated in 2013, in February 2020 the station was served by 75 trains daily (189). There are one to two trips per hour to and from both Bologna and Milano, and trains to major cities such as Milano, Bologna, Firenze and Rome are available until approximately 11 p.m. daily (190).

Impacts of HSR

While the monumental station design was meant to bring new life to the region, local authorities did not come together to plan for new development around the station prior to the station's opening (188). However, more recently local authorities have identified the need for local public and private entities, including the region, the municipality, as well as the freeway operator, universities, and the local Chamber of Commerce, among others, to collaborate on improving local accessibility and making the region more attractive. Recent plans to develop the station-area include new commercial and industrial developments on the Industrial Park Mancasale and farm-to-fork activities to promote local agrobusiness (187).

The station-area initially did not attract the expected retail and commercial activities and was thus perceived as empty and degraded prior to its inauguration (188). As reported by representatives of the station operator, Rete Ferroviaria Italiana (RFI), the struggle to find retail businesses interested in locating at the station persists. However, the station has attracted some new businesses; for example, in early 2023 a municipal pharmacy opened in the station complex across from the passenger entrance. Still, the station operator and the municipality continue to work on finding uses for the vast empty spaces within the station that are currently underutilized, including 10,000 square meters in the basement level (189). RFI, along with the Italian Ministry for Infrastructure and Transportation and the regional government, are planning to rehabilitate the underpass in the hope of attracting additional services and businesses such as restaurants and bars, creating more welcoming and better-connected waiting and working areas, and giving life to a planned exhibition area (191).

In terms of intermodal connectivity, the station was planned to be easily accessible by car from a vast catchment area; there are easy connections with the main Milan-Bologna freeway (A1), the Autobrennero Bologna-Verona freeway (A22) and the Reggio Emilia's northern bypass highway (183). Eighty percent of the station users reach the station by private car (187). To respond to a scarcity of parking spaces, large parking sections have been recently added next to the station, leading to a total parking capacity of 2,400 spots (192). To accommodate drivers, the cost of parking is kept low, with the first hour free of charge and then a cost of 1.5 Euros per hour, with a maximum cost per day that cannot exceed 7 Euros. There is also a subscription available for regular travelers, who pay 400 Euros for unlimited parking at the station all year round (192).

According to the municipal plans, the expanded parking areas will be supplemented by 1,000 new trees to offer shade for vehicles and help offset some of the carbon emissions generated by car use (189).

According to RFI data from 2018, only 5.4 percent of the station users reached it by public transportation that year, mostly due to the lack of satisfactory transit options (183). A bus line (*Linea urbana 5*) connects the city center with the station about every 24 minutes (183). However, this frequency is considered unsatisfactory by many users and the bus line does not operate 24 hours a day (193), making it unpopular. Moreover, the peripheral HSR station is not connected to the regional train network, which departs from a distinct historic station in the central core of the city (183), and lacks feeder services to the HSR station.

To remedy this lack of satisfactory public transportation options, the municipality has developed the *Tappeto Rosso* (Red Carpet) project that has been included in the most recent urban mobility plan (PUMS) (193) and focuses on better connecting the city center and the station through expanding public and active transportation by redeveloping a major urban axis between the two (187). Special lanes are being planned and will be dedicated to public transit on Via Gramsci, the main road that will also be redesigned to accommodate pedestrian and cycling needs (193). The municipality is also planning to create a tramway/streetcar to connect the city with the station more sustainably (186) (193), but this large 282.3 million Euro project is still awaiting approval by the Ministry of Infrastructure and Transportation (186). Thus, although this mobility project includes active and public transportation, the car is likely to remain the primary means of access due to high road accessibility and available parking spaces around the station, and the limited availability of other viable options (193).

It appears the station has not generated a dormitory effect. According to information provided by RFI, most travelers are local residents (about 40 percent of station users come from the City of Reggio Emilia), who only use the station occasionally. Furthermore, the number of weekly trips has progressively decreased between 2014 and 2018 (183). Currently, only two percent of travelers use the station daily, while 43 percent of users report using it rarely. Among those who use the station, most do so for work purposes, since 37 percent of travelers are business workers (187), while 23 percent use the station to visit family or friends (187). Hence, station users do not use the station daily to travel to another city, which would suggest it has not had a dormitory effect. Moreover, it seems that no substantial number of people have relocated near the station to better utilize HSR services. This absence of new residents near the station and the distance from the central core of the city of Reggio Emilia suggests that the station has not significantly impacted the housing market in the area.

Relevance for California

The case of the Reggio Emilia Mediopadana AV Station shows that the lack of coordination among local actors to foster development around a new HSR station can substantially hinder its success in attracting passengers along with businesses and economic activities. Moreover, the peripheral location of the station has created significant challenges to attracting riders and developing access to the station via sustainable modes of travel. Indeed, the combination of limited public and active transportation options combined with the presence of

faster and more efficient connections via highways, means the station is primarily accessed by private automobiles.

The struggles of the Mediopadana AV station also resemble those of another new peripheral HSR station in Italy. Napoli Afragola, similarly located in the periphery of Naples, in the Afragola municipality, was inaugurated in 2017 with the expectation of becoming a major gateway to the large metropolitan area of Naples. It shares many similarities with the Mediopadana AV Station in Reggio Emilia (183). Napoli Afragola Station was designed by another star architect, Zaha Hadid, as an architectural landmark for the area. Similar to the Mediopadana AV station, Napoli Afragola is currently poorly connected to Naples' historical center via public transportation, although there are plans to connect the station through the metro system in the future (183). As reported by RFI representatives, Napoli Afragola Station has also struggled to attract users and generate economic development in the surrounding area.

The cases of Reggio Emilia Mediopadana AV and Napoli Afragola are very different from those of central stations such as Milano Garibaldi and Roma Tiburtina,[3] which have grown considerably in recent years, after the opening of HSR services on the Turin-Milan-Bologna-Florence-Rome-Naples- Salerno corridor. These central stations stimulated important real estate development along with growth in business and retail activity after the initiation of HSR operations. This suggests that peripheral stations in Italy have faced common struggles, while central stations have achieved greater success in generating positive economic development in their surrounding areas. It is also possible that central stations might have more easily benefited from pre-existing local opportunities and a higher degree of centrality and accessibility, while any impacts that peripheral HSR stations will generate might take more years to manifest.

The lessons learned from the Italian examples offer some important implications for the California HSR system. Providing appropriate connections to peripheral HSR stations with public transportation feeder lines and coordinating and planning for development surrounding the station seems to be essential to promote local development and access by non-car modes. While many differences exist between Europe and the United States—which might limit the ability to draw conclusions on these findings—it seems likely that, especially in the U.S., which already features higher levels of car dependence, peripheral HSR stations will rely to a higher extent on driving for access.

Further, the ability to generate economic development in the areas around stations might remain uncertain, even if proper coordination with local planning agencies, businesses and developers might spur economic activity and redevelopment opportunities, in particular in regions such as California where there are more low-density car-oriented developments. This model of development might substantially affect the design and accessibility of station surroundings, due to the greater need for parking and the lower densities usually

[3] Both Milano Garibaldi and Roma Tiburtina were historically smaller stations, with lower traffic than the more central stations of Milano Centrale and Roma Termini, respectively, in Milan and Rome, but they experienced substantial increase in their importance and volume of travelers after the arrival of HSR service.

associated with car-oriented developments, which could limit the benefits of HSR in terms of accessibility and capacity to serve passengers.

Reflections and Conclusions

High-speed rail systems require large financial investments and involve a significant amount of infrastructure, which have the potential to deeply change the regions in which they are deployed. California has an ambitious HSR plan, being implemented in phases. By the time the California HSR system is completely built, the accessibility and travel options between most cities in the state will change substantially. While plenty of attention has been focused on the ridership forecasts for the California HSR network and the direct impacts on job creation in the construction sector, other indirect impacts of HSR have not received similar attention. This project was designed to fill this gap. The study investigates the potential indirect impacts that HSR could have on economic activities and urban development of California cities.

Understanding the conditions that might lead to certain impacts from HSR on the regions that it serves is of fundamental importance to promote economic development, spur synergies with urban planning and policymaking, and create conditions conducive to harvesting desirable impacts (while minimizing eventual negative impacts). Not all cities connected to an HSR network experience the same impacts. As the experience from regions abroad in which HSR systems have been in operation for many years show, certain stations have underperformed with respect to development expectations, while other stations have delivered their potential of (or even exceeded expectations) attracting development and spurring urban regeneration.

Overall, the launch of new HSR services in a country can lead to:

- *Economic Impacts* (e.g., on jobs, firm relocation, real estate development, land value changes, housing development, gentrification, regional development)
- *Physical Impacts* (e.g., land use changes, station-area development, infrastructure development)
- *Social Impacts* (e.g., population growth or decline, socio-demographic changes)

The review of the relevant literature shows that the most documented HSR impacts are economic, such as real estate development and job creation, followed by physical impacts, and environmental impacts (especially modal shifts and emission reductions from air and road travel). Only a few studies discuss social impacts, such as gentrification and population growth, or mention changes in urban policy or planning regulations (e.g., zoning).

Further, as the impacts of HSR on economic and social activities, and the urban development dynamics of cities, often take years to appear; their effects are often confounded with the impacts of other factors, such economic cycles, changes in the local economies and urban form of cities, and the impacts of local policy and planning. This might make those impacts attributable to the HSR deployment more difficult to isolate, at first sight. For example, HSR might lead to positive impacts to a region, even if the economy of the region worsens over time, if the HSR deployment helps reduce the impacts of the economic downturn on local activities; or HSR might not lead to any substantial positive impacts for a region, even in the presence of an expansion of

economic activities and urban development, if these are the results of other factors unrelated to the deployment of HSR. The review of the relevant literature in this field and the analysis of case studies from HSR station-cities and HSR corridors in Europe can help provide insights into these issues.

Overall, this study addresses the following main research questions:

- To what extent have HSR systems in European countries contributed to creating jobs (beyond short-term jobs, e.g. in the construction sector) by attracting new businesses and firms in station-cities? What have been the most important preconditions for job growth to take place?
- To what extent have HSR systems in European countries affected local real estate markets, including impacts on land values or rent in station districts? How has the impact on real estate markets varied by the type of station-city (first tier, second tier, exurban, etc.) and by station-district location (central vs. peripheral)?
- To what extent have HSR systems increased residential and/or commercial development in station areas, and what type (market rate, affordable) did they attract? What have been the most important preconditions for residential and commercial development to take place?
- To what extent have HSR systems increased other economic activities in station-cities, such as tourism or business firm location?
- Have economic benefits from HSR systems accrued throughout the HSR corridor segments (*regional effect*) or been largely concentrated in some station-cities but not others (*localized effect*)? Has the HSR system contributed to the economic diversity and success of both smaller cities and primary cities?
- What have been the social equity implications of HSR-induced economic development in terms of new housing and new jobs? What have been the impacts of the changes on housing markets?
- Are there particular policies (at the municipal, regional, state or federal levels) that can contribute to successful economic impacts from HSR services?
- To what extent are the lessons learned from HSR systems abroad transferable to the HSR program in California? Which factors may limit the transferability of the lessons learned, and how can they lead to potentially different outcomes in the state?

In the following sections, we briefly summarize our main findings from this project, grouped by types of indirect impacts of HSR. We then discuss the transferability of these lessons to California.

Impacts on Economic Activities

High-speed rail projects are often promoted as an opportunity for economic development of the regions they are traversing. The review of the literature and case studies from European HSR systems help us understand the conditions under which such expectations of positive impacts on economic activities have materialized. Further, HSR systems can bring economic benefits to local and regional economies, but not all station-cities

benefit equally from the introduction of HSR services. Previous studies from Japan, France, and Germany show how HSR systems might lead to impacts on population and employment growth, ridership, business behavior, real estate values and activity, employment, and residential location, among others. The impacts of HSR can be highly variable and largely depend on local characteristics of how HSR systems are deployed.

The literature shows that the size of a station-city, its position in the regional hierarchy of cities, and its distance from first-tier cities on the network may influence the economic performance and type of impacts stemming from HSR projects. Other important aspects affecting the outcomes include the station location within the city, the station connectivity and intermodality, the type and level of HSR service, the preexisting cultural or tourist assets and amenities that may receive a boost from the arrival of HSR, the condition of the local economy, as well as the type and extent of government planning and intervention.

Indeed, in many European countries, cities have sought to use the presence of HSR to develop and attract industries that had no prior presence or history in their region. However, the expectations for economic development associated with the deployment of HSR have not always materialized. For example, the review of the literature shows that it is often difficult to change the nature of economic activities of a city reached by HSR to attract industries from other economic sectors. Le Creusot, discussed in this study, is emblematic of this type of failure. Expectations with HSR deployment in this city were linked to the reconversion of the local economy to attract high-tech industries, which were traditionally not located in the area. The failure to attract this type of new industries to the region highlighted how a HSR project alone could not attract and promote the development of completely new industries, without prior history and local labor force suited for these economic activities.

Economic development is more commonly achieved through promoting the expansion of existing economic activities, which can benefit from the increased accessibility brought by HSR service. The case study of Zaragoza demonstrates how the arrival of the HSR network in this city helped boost the growth of existing industries, thanks also to the coordination with urban planning and zoning regulations, which were articulated during station design and implementation. In this case, HSR contributed to boosting the economic activities of the city, raising its status in the economy of Spain.

Several previous studies have examined HSR effects on job concentration and relocation. For example, they showed that job decentralization from Paris did not take place because of the TGV in France. Instead, firms from other cities opened offices in Paris, while Lyon also benefited from HSR deployment with fewer Lyon-based firms relocating to Paris after the Paris–Lyon line was built. Instead, second-tier cities such as Le Creusot faced difficulties in attracting firms. Still, firms benefited from the availability of high-speed rail, because one-day round-trips on the TGV network allowed them to expand their operating zone, enhance coordination among their different geographic units, and even achieve economies of scale. Looking specifically at Lyon, one study found that its firms benefited greatly from the enhanced accessibility and greater exposure and linkage to Parisian markets through HSR.

Similar evidence from Germany and Italy shows how the expanded HSR network benefited the economy of several intermediate stations served by the network, and the greatest positive economic impact was in the counties nearest to the stations newly-served by HSR. Similarly, HSR produced significant accessibility benefits for areas along its network and, in the case of Italy, positive economic impacts across the country, with the regions connected by HSR service growing their GDP at approximately twice the rate of regions not served by the HSR system. HSR, however, had some negative regional equity impacts in terms of travel time accessibility for those areas not served by HSR, which were left behind.

The central location of many HSR stations has been key to their success in European countries. For example, this was the case for Le Mans station, where HSR helped turn the station into a well-connected transportation hub. Not surprisingly, stations located in the central core of the city can be more easily integrated into the existing transportation networks and serve it with multiple feeder services, to accommodate access/egress of passengers. This high level of intermodality and connectivity helps achieve sustainability goals and has helped promote development projects around the stations. The type of economic activities attracted by more peripheral stations is also often different—for example, the case study from Reims shows how the peripheral station of Champagne-Ardenne TGV uniquely attracted larger firms and a significant number of industrial activities, including industrial headquarters, scientific/technical activities, administrative/ support and accommodation/catering services, differently from the firms that located near the central station, which had a larger proportion of high-level service activities, such as financial or insurance services. Many of the firms that locate near peripheral stations do so because they benefit from the large office space availability and cheaper real estate values in the station area.

Another important aspect of HSR impacts on economic activities relates to the ability to stimulate business travel (including travel for conferences, exhibitions, trade fairs, and corporate events) and tourism. The former is traditionally associated with the arrival of HSR service, while the latter has also received increased attention, including the impact that newer low-cost HSR services such as OUIGO in France have been found to have in attracting price-sensitive customers and stimulating leisure trips that would not have otherwise taken place. Evidence from Paris and Madrid shows how fast HSR service accommodates tourists wanting to visit Paris, while in Spain, they are also important for foreign tourists already visiting Madrid as a means to visit other Spanish tourist spots, thus expanding tourism in other regions of the country. A similar effect, if obtained in California, could help promote tourism in central parts of the state, including mountain regions, which would become more easily reachable from other areas.

Scholars have observed that in the big Spanish cities of Zaragoza (along the Madrid–Barcelona line) and Cordoba (along the Madrid–Seville line), several businesses (meetings and consulting work) and tourism have benefited from the advent of HSR service. Similarly, a study from Italy showed that destinations served by HSR attract more Italian tourists, and tourists spend more nights at those destinations than alternative locations not served by HSR. However, the experience from France also shows that in certain cases, HSR might lead to an increase in the number of tourists, but the average duration of their stays decreases. This is particularly the case for travelers visiting the city for conferences or events, such as MICE (Meetings Incentives Congress and Events) travelers, who now have easier access in and out of town with HSR service.

Impacts on Real Estate and Land Values

Among the impacts that have been observed in this study, HSR projects often contribute to economic development through the growth in real estate projects and increased land values. This is often the case in cities with centrally located HSR stations, which are more easily accessible and better connected. Stations that are more peripherally located and less connected to the central core of the city have often experienced disappointing ridership numbers and less relevant impacts on socioeconomic activities in the region. These stations usually require special efforts to increase their connectivity with multimodal alternatives like public transportation, bicycle lanes and bikeshare systems, in addition to road transportation and parking facilities to access the station.[4] In order to prevent or avoid the barrier effect associated with the location of railway tracks, better connectivity may also imply burying the tracks to increase pedestrian accessibility, which can become expensive if it is not planned from the beginning of a HSR project.

Examining HSR station-areas around six mid-size European cities (Strasbourg, Arnhem, Stratford, Cuenca, Kassel, and Liege), a study finds that different intervention strategies followed by their municipal governments (e.g., connecting the station to other modes, mitigating the station's barrier effect, consolidating a station's urban image) have led to urban regeneration around their HSR station-areas. Similarly, Lleida, another mid-size city in Spain utilized its historic railway station to accommodate HSR service, which stimulated development in the station's vicinity.

The literature shows that different HSR cities may encourage concentration of different types of land uses around the HSR station. Thus, residential uses have flourished in several locations. For example, an early report that reviewed development around HSR stations in different countries to identify opportunities for the California HSR program found multi-family housing to be a prominent land use in areas adjacent to many HSR stations. Another study focusing on France and Japan found evidence that residential location choice takes into account the presence of HSR. This is apparent in our case study of Vendôme, France, where the construction of HSR was associated with a significant reduction in travel time to Paris (now only 40 minutes away) and an influx of Parisians to the city, which altered the local real estate market. Ciudad Real in Spain was also able to attract to the station-area a range of uses that require cheap land, including multi-family housing. At the same time, demand for housing around a station usually depends on whether potential consumers are locals or immigrants, and renters or owners.

A range of commercial uses may also be attracted to the area adjacent to an HSR station. Evidence from the literature on station-area development in Germany and France shows that the growth of commercial uses in HSR station districts is more common in first-tier cities, while residential and cultural uses benefit secondary cities. In Lille, station development plans have included convention, entertainment, hotel, and office spaces, transforming the central city district. Similar experiences from other European cities show that areas around

[4] These type of infrastructure and feeder service improvements are more difficult to deploy in regions with traditionally lower demand for these services, in a difficult cycle of cause and effects, highlighting the difficult investment environment that often affects these cities.

HSR stations, in central cities in particular, have witnessed an increase in land values and rising demand for office space. In Rotterdam, the city developed an ambitious station-area masterplan for its new HSR station that opened at the heart of the central district in 2014, which has attracted several high-profile real estate projects. If a similar effect could be obtained in the San Francisco region, HSR could offer an opportunity to revitalize and bring economic activities and retail development in the large (but currently underutilized) San Francisco Transbay Transit Center.

Focusing specifically on temporary office space that meets the growing demand of flexible ("nomad") workers, HSR can promote the growth of business centers built at or near HSR stations. For example, in Italy such business and service centers have developed at the HSR station-districts in Turin, Milan, Rome, Florence, and Bologna. Similarly, in France, in addition to the EuraLille business center in Lille, the city of Les Mans saw the development of the new Novaxis business center near its HSR station, while more recently, business parks and business centers have been built around the HSR stations in Reims, Metz, and Strasbourg.

In summary, the literature indicates that the launch of HSR service may serve as a boost for real estate development in the adjacent station area, but this needs to be facilitated by anticipatory planning (e.g., creation of a station-area masterplan) that considers which type of land uses are the most appropriate. Station-area development is also positively impacted by a central station location that is well-connected to various destinations within a city, as well as frequent HSR service that connects the city to major metropolitan centers. On the other hand, station-area development may not occur in a weak real estate market, or where there is a lack of population and economic growth, available alternative development sites, or intermodal connections to the HSR station.

The Reims experience also reveals that centrality is reassuring to firms and developers. During the 2008 crisis, building development and the establishment of new firms around the peripheral station were slowed down, while this did not happen around the central city station. It is possible that developments around Californian peripheral stations could also be similarly sensitive to economic conditions.

Land costs are a crucial aspect of real estate development, and a few studies have explored the impact of the HSR on land values. The results have been mixed, which again indicates that context matters. Some scholars find a positive association between the arrival of HSR and increases in land values. For example, a study finds that the opening of the TGV Atlantique line connecting Le Mans to Paris has coincided with a major increase in the city's land values. Examining the impact of the initiation of HSR service on land values and housing values in Ciudad Real—a small city with a university in the Castilla-La Mancha region of Spain—another study found that the city saw an increase in both real estate development and land values with the opening of the HSR station, which in combination with the presence of the university, led to an increase in immigration and population growth in the city. Other studies from German cities find more limited impacts on real estate and land values.

In general, these topics should be carefully assessed, due to potential for changes in land value and real estate costs that have inequitable impacts on the local population, vulnerable and already marginalized communities.

and possibly leading to gentrification and the eventual displacement of members of lower-income households and minorities.

Long-distance Commutes

Dynamics between cities can change with the deployment of HSR systems. This includes effects such as population shifts across cities and changes in commuting flows over longer distances allowed by HSR, leading to the creation of larger and interconnected metropolitan regions. This effect usually tends to wind down beyond one hour of travel by HSR (up to 300 km). Not surprisingly, not all segments of the population benefit from the increased possibilities of commuting over longer-distances allowed by HSR systems, due to the high fares. Long-distance commutes promoted by HSR are more common for white-collar workers and those who can more easily work remotely or in hybrid settings (and do not commute every day).

For example, a study from Spain estimating the HSR impacts on labor migration in three main Spanish interregional commuting corridors (Madrid-Toledo, Barcelona, Andalucía) finds that HSR facilitates commuting between regions in the 30- to 70-minute range, thus encouraging labor mobility, in particular for higher-income workers, if rail operations are compatible with their work timetables. The higher rents in large metropolitan areas, combined with the presence of HSR service, help increase the number of commuter trips and, thus, the number of people living outside the city and commuting for work.

Relevant examples of these types of effect include Ciudad Real, where the short ride on HSR to Madrid allowed some workers to live in Ciudad Real and commute to the Spanish capital for work. Once in operation, the HSR service in Valladolid also favored skilled workers who could better access jobs in the Madrid metro area, increasing the opportunities for some people to live in Valladolid and work in Madrid. This has benefited those with the qualifications and the types of jobs that allow this flexibility. Similarly, many passengers using HSR from Vendôme, in France, travel back-and-forth to Paris for work and, according to some, Vendôme has become a dormitory for some Parisian workers.

The ability of HSR to promote the establishment of commuting patterns over longer distances and among those who do not commute regularly to their workplace suggests that this type of impact might be more common in the post-pandemic society with increased adoption of hybrid work schedules mixing some physical commuting with some remote work, either on the same day, or on different days of the week. The literature in this area does not provide strong evidence of this, though, probably due to the recent occurrence of the pandemic, and the limited ability to study its impacts on a niche market such as HSR. The case study of Vendôme, discussed in this study, does highlight how HSR can support the move of remote/hybrid workers to smaller cities, with important implications for the real estate market and rental values in these cities.

Since the pandemic, the possibility for remote work has generated increased interest in rural areas served by HSR. As it has recently occurred in Vendôme, former urban residents could also move to California's exurban station-cities, which are only 20-40 minutes away from metropolitan centers (e.g., in the case of Palmdale or Gilroy). They could work remotely on certain days and access metropolitan centers periodically for work

meetings, as well as access amenities and recreational services. The arrival of residents with higher incomes from larger metropolitan areas, on the one hand, offers these residents housing options at a lower cost than in the first-tier cities. This increases demand for local real estate and increases land values and rents. As discussed at the end of the previous section, as a result, local residents might be unable to purchase or rent spaces, and some may be eventually forced out of the real estate market, unless policy makers and planners initiate inclusive zoning and other anti-displacement strategies.

Geographic and Temporal Aspects of HSR Impacts

The evidence, to date, from countries where HSR systems have been in operation for many years confirms that HSR can have a non-negligible role in promoting and redistributing economic activities and growth of different land uses, often at the expense of locations it bypassed. Even so, a number of intervening factors can enhance or diminish the economic impacts of HSR systems on a city. These include city size and position on the HSR network (i.e. distance from major metropolitan centers), type and frequency of HSR service, station location and connectivity to other travel modes, condition of the local land market and regional economy, coordination with regional and local planning and policy, as well as pre-existing city amenities and assets (e.g., type of existing industries, presence of tourist sites, etc.).

The evidence collected in this study shows that the indirect impacts of HSR are usually greater for on-network and first-tier cities, while the effects are limited for relatively less central and smaller cities, especially in the absence of carefully constructed policies. Research has shown that HSR-driven job growth is usually highest in the central core of urban areas, and cities with HSR stations (especially those centrally located in the urban area) have fared better in terms of job growth.

Not surprisingly, labor market impacts of HSR tend to be point-specific, and clustered in the cities directly served by a HSR station, not spread along the entire corridor. Further, the size and connectivity of the HSR network is usually key to greater impact, as shown in the case of the relatively short, isolated HSR corridor built in Galicia (and also the initial shorter corridors in Italy), which had more impact on economic activities and urban development after they were directly connected to the rest of the national rail network.

In addition to the main metropolitan areas and first-tier cities, research shows that other cities may also benefit from HSR by acquiring greater visibility resulting in catalytic effects on growth and development, as for example in Lyon and Lille in France, and Sevilla and Zaragoza in Spain. Other smaller and intermediate-sized cities on the HSR network, reachable in less than one hour away from the major metropolitan centers, often experience significant population growth, thanks to their integration in the larger metropolitan network, which helps them attract economic activities and especially housing investments due to the longer-distance commuters who choose them as their place of residence. Under certain circumstances (e.g., good station location and feeder urban transportation services), particular small cities on the HSR network that are less than 100 km from a major metropolitan center have shown to have the potential to transform into metropolitan sub-centers. This effect declines with distance, and tends to disappear for locations with travel time of more

than one hour (up to 300 km, depending on the HSR service) from major metropolitan centers. Some scholars also argue that HSR may extend the spatial reach and economic role of exurban "edge" cities, particularly where it provides access to airport facilities.

Additional research on HSR in Spain shows that HSR cities have more often experienced positive population growth relative to similar non-HSR cities; in some cases HSR provided a benefit for small, isolated cities, but in the end, population growth depends on the extent of each city's transportation changes, the time elapsed from the launch of the changes, and the location and size of the city. Local economic dynamics and stakeholder behaviors are very important to the overall development of the city.

Locating a HSR station in the central core of the city has been found to benefit the local economy to a larger degree than more peripheral stations located in the outskirts of the city. Among the cases discussed in this study, for example, the central location of the Le Mans station was key to making the station a well-connected transportation hub. This phenomenon is strongly connected with the integration of HSR into existing public transportation services, to expand the catchment area of the station beyond the limited reach of active modes of travel (walking and bicycling) and private vehicles. Stations that depend on automobile access require larger parking areas—not always available adjacent to the station— reducing the space available for urban development around the station, which limits opportunities for accessing the station by walking or bicycling. For example, local authorities in Le Mans insisted upon obtaining HSR service through a central station rather than a peripheral one (the latter being a common solution for many French intermediate cities served by HSR). The station was built next to the historical railway station served by conventional rail and is connected to local transportation options and conventional rail (feeder) services. Le Mans has attracted better development than other comparable cities, and it is often considered a success story in terms of HSR impacts on the development of the city.

Under the right circumstances, peripheral stations are also able to attract development. The case study of Reims, for example, shows that the arrival of HSR led to the creation of a mixed-use neighborhood with diverse services, office space, and housing units surrounding its station located outside of the city's urban core. This district attracted large industrial companies compared to the smaller tertiary firms located near the central station in the same city. This experience suggests that peripheral California HSR station-cities, such as Palmdale, could also attract larger industrial businesses in need of locations with good accessibility but cheaper land than in central parts of Los Angeles.

In general, though, peripheral stations in Europe have, on average, performed more poorly than centrally located ones. These peripheral stations have been nicknamed *gares du désert* (stations of the desert), or *gares-betterave* (beetroot stations), because of their isolated and often disconnected location on formerly rural land. Examples of this type of poorly performing stations can be found in the case studies of Le Creusot and Vendôme in France and Reggio Emilia in Italy. Impacts of HSR on local development in all these cases were below expectations. The low performance of the Mediopadana AV station in Reggio Emilia is also similar to that of Napoli Afragola—another new HSR station poorly connected to Naples' historical center via public transportation—since both have struggled to attract users or generate economic development in their

surroundings. In Vendôme, the ability to attract new economic activities near the station has been very limited, but the city has started to gain population and new residences since the first COVID-19 lockdown, due to a growing influx of individuals from the Paris region, who have increased the demand for local real estate and boosted real estate prices. In general, access to these peripheral stations by non-motorized modes and public transportation is poor, and most users reach the station by private car.

The Delicias HSR station in Zaragoza was not located in the city center but rather in an area that had potential for urban development. This can also happen in some California station-cities that build HSR stations in more peripheral areas. In such cases, the station's connectivity to other parts of the city, as well as other cities on the HSR network is very important. Zaragoza has witnessed continuous and increasing demand for its HSR service, as it serves the region of Aragon, which is well-connected with other areas by train and bus. The Delicias HSR station's intermodal characteristics have also contributed to making this station a successful transportation hub. At the same time, Zaragoza has particularly benefited from its location on the most important transportation corridor of the country, almost equidistant from Madrid and Barcelona.

The case studies of some Italian and French HSR stations located in the outskirts of the cities paint a stark contrast with other more central HSR stations in major cities. For example, the impacts of Reggio Emilia Mediopadana AV and Napoli Afragola are very different from those of central stations such as Milano Garibaldi and Roma Tiburtina, which have grown considerably in recent years after the opening of HSR service on the Turin-Milan-Bologna-Florence-Rome-Naples-Salerno corridor. These central stations stimulated important real estate development along with business and retail activity growth after the initiation of HSR operations. This suggests that peripheral stations in Italy have faced common struggles, while central stations have achieved better success in generating positive economic development in their surrounding areas.

Scholars find that the economic impacts of different HSR projects may vary in the immediate, short, or long term. Seeking to isolate the role and impacts of HSR from other factors influencing a city's or a region's economic development is a major challenge, especially in the long term. This is true because it is difficult to observe and differentiate the impacts that come directly from the arrival of HSR service from those related to wider economic trends present in a city or region.

It is therefore possible that central stations more easily benefit from pre-existing local opportunities and higher degree of centrality and accessibility, which spur economic development in the short term, while the impacts from peripheral HSR stations might take more years to become manifest. As discussed earlier in this chapter, many indirect impacts of HSR might take many years to appear. These indirect effects are more easily confounded with the complex impacts of other city-specific factors, such as economic cycles, urban development patterns, local policymaking, and local migration patterns, which might manifest themselves over the same years.

Coordination with Local Policies and Visions

This study has collected ample evidence that the impacts of HSR might vary significantly with the local context, and can be enhanced by the coordination with local policies and strategic visions for development. HSR service and stations alone cannot guarantee economic growth and urban development. This is because HSR can bring economic effects to station-cities but by itself is not a pure economic catalyst. It needs to be complemented by anticipatory planning and public capital investments, ensuring a good level of HSR service, connectivity of the HSR system to other transportation modes, and coordination with land use planning and investment strategies, among other things. The cities of Le Mans and Zaragoza, discussed in this study, are examples of where this coordination seems to have worked well.

Coordination with local policymakers and stakeholders on a collaborative strategic vision for HSR development can help expand the impacts of HSR and foster greater economic convergence across on-network and off-network cities. This coordination could span various matters from the relocation of firms and economic activities to bringing in new business such as tourism, hospitality, or high-tech companies, which would benefit from the increased accessibility brought by HSR and feeder transportation services, combined with the availability of local amenities and synergies with local businesses.

One success story is discussed in the case study of Le Mans. Two years prior to the arrival of HSR, local public and private actors collaborated on preparing strategies to optimize its impact. Among other actions, the city, the association of surrounding municipalities, and the local Chamber of Commerce formed a committee to plan the development of a business park adjacent to the station. The business park promoted the renewal of formerly forsaken areas south of the rail tracks, as part of a larger "technopolitan" project promoting the development of new technologies and technological parks, led by local authorities in an effort to boost HSR economic development. In addition to the business park, the vision led to the creation of the "Technopole Université" south of the station, home to the University of the Maine campus, and an additional "Technoparc" focused on attracting automotive companies, capitalizing on businesses already present in the city. The Le Mans station and associated strategy for development are often described as a success because they were able to attract new firms and jobs to the city thanks to the early mobilization of authorities and the collaboration and coordination of different entities and actors. These led to a successful plan for the arrival of HSR and associated development of the region. Local authorities also saw the opportunity to use HSR service to promote tourism and were proactive in planning and initiating a number of attractive tourist activities. Lastly, the pandemic increased remote working opportunities and reduced the time that employees needed to be physically in the office. These combined with the fact that the city is only one hour from Paris by HSR, have helped to increase the number of people moving to Le Mans, and living and working remotely from there. Additionally, Le Mans station's intermodality and centrality enable HSR riders to reach the station easily via public transportation.

The arrival of HSR provides regions with new economic opportunities but development strategies and the involvement of local authorities are critical in exploiting that potential, in particular to create synergies with existing activities and to harvest the potential of the region. In particular, it can be useful to firms connected to

the local economy and labor skills, which suggests that California's small station-cities should plan to attract industries and firms relevant to their local context.

Some of the case studies discussed in this report highlight instances in which the lack of coordination between the launch of HSR service and local planning and policy-making led to outcomes that were below expectations. This can happen for various reasons. For HSR stations located in more peripheral areas, it is essential they are well connected to town centers through adequate public transportation and other transportation options. The lack of success of the station-adjacent technological park in Vendôme, for example, has been largely attributed to the limited attractiveness of the location, and the city's HSR station's poor transportation connections to the city center.

Another interesting case is Reims, where the local actors largely failed to seize the city's potential for tourism. They did not coordinate communication strategies and did not push for the expansion of hotel spaces, touristic events, etc.

On the opposite end of the spectrum is the case of Zaragoza, where the arrival of HSR led to the successful redevelopment of the area around the city's HSR station. The city took advantage of the infrastructure development required for HSR to design not only a new station but also to re-envision the area surrounding it. The city created a plan for this area, which included new large-scale buildings that became important landmarks. The city hosted the World Exhibition in 2008, also creating a new industrial-logistic park and new industrial activities. The infrastructural and economic regeneration of Zaragoza was supported by urban marketing as part of a strategic planning process that the city began during the 20th century by drafting an ambitious strategic plan, which helped keep its urban planning and transportation objectives aligned. The strategic vision for the city and surrounding areas allowed Zaragoza to capitalize on both the arrival of HSR and the hosting of the World Expo, generate local economic development, and promote transit-oriented development around the station.

The case of Zaragoza shows that HSR station-areas that have the benefit of a well-developed and articulated urban plan can promote and accelerate adjacent development. Development around Zaragoza's first two stations was more residential and spontaneous, while the remodeling and expansion of the city's HSR station was carefully planned and integrated with the strategic plan of the city promoting a variety of land usest. Strategic land use planning around the station has the potential to attract more development in station-adjacent areas and increase the economic activity of a city.

Translating the Lessons Learned to California

The cases discussed in this report provide some lessons for the California HSR program, especially the caveats regarding the steps necessary to encourage economic growth and development around HSR stations, and the importance of considering local characteristics, and coordinating policies in shaping these plans. Of course, we acknowledge that transferring experiences from one context to another is difficult, in particular considering the differences between the U.S. (and California) society and European countries. Still, we believe that the

general implications from European HSR projects discussed in this report remain valid, and the lessons learned can inform the California HSR program, to some extent.

Because European HSR networks have been developed over the last 40 years, studies focusing on these projects provide valuable insights for the California HSR system, to help understand the potential impacts that might derive from the deployment of HSR systems, beyond the initial years of operation, and over the next few decades. And they help identify what strategies and policies can promote positive economic development, while limiting any negative consequences.

HSR authorities should work with a variety of planning agencies and local stakeholders to develop a comprehensive strategy that integrates HSR infrastructure development with the visions of the cities that will be affected by the project. Considering the importance of station locations in the success of HSR investments in fostering economic development, HSR network and station site selection (and design) should be made in collaboration with local planning authorities to create a synergy between urban plans and HSR infrastructure development.

The research and case studies presented in this report on the European experience points to the larger success usually associated with centrally located stations that are well integrated with local transportation services, and accessible by alternatives to private cars. We find that building on the characteristics of the local economy and harvesting synergies with existing economic activities in sectors that are already active in a region are usually more successful and easier to turn into reality than employing HSR as part of ambitious plans to generate economic activities not present before. From this perspective, the contribution of HSR to the local economy should be seen more as *incremental* rather than *transformational* (or entirely revolutionary) for the local economy of the city.

Land use development is an important component of the economic impacts that HSR brings to a region, and there are expectations that California cities might benefit from some of these effects, similar to what happened in several European cities. Integrating HSR stations into the urban fabric of a city leads to more positive impacts in terms of land use development. It is also less risky and more reassuring for developers and investors in times of economic uncertainty, with lower likelihood that plans get canceled or postponed.

The existing evidence shows that due to its high speeds and ability to serve longer distances, HSR operations can attract white-collar workers, who can more easily work remotely, and thus, have more flexibility in adapting their commuting patterns, or moving to less central cities, once it is connected to major employment centers. Like Paris and Madrid, the larger cities in California, San Francisco and Los Angeles, are more expensive than the intermediate locations on the planned HSR network, facilitating people moving out from them to cities in the Central Valley, while at the same time allowing them to commute to their jobs, attend business meetings and access facilities and amenities, when needed, in the larger metropolitan areas in Northern and Southern California. Considering the increasing real estate prices in metropolitan cities in California, the importance of service, government and high-tech sectors in the state, and the increased adoption of remote and hybrid work

after the COVID-19 pandemic, the effect of HSR on commuting patterns could be even more pronounced in California than what has been observed so far in European contexts.

These lessons may be relevant for exurban cities on the California HSR, such as Palmdale or Gilroy, that are located on the outskirts of large metropolitan areas. Such cities may consider activities that are synergistic to HSR and can help increase their development potential. Local authorities in Gilroy, for example, could take advantage of the coming of HSR to rejuvenate and expand their garlic festival, while in Palmdale, the city could boost its aerospace image for tourists interested in aviation and the city's airparks. As the cost of real estate in these two cities is lower than at the center of their respective metropolitan areas, they may also see an increase of remote workers living there. This would only happen if these cities are perceived as attractive for workers to live in, and the location of HSR stations is convenient and HSR service is also well-integrated into local transportation networks.

The integration of HSR stations and tracks in the urban and natural environments is also a very important issue to consider in terms of design solutions adopted for the HSR system. Long tunnels and viaducts have been constructed on some European HSR lines to reduce the surface impact of the tracks and better integrate them in the urban and natural environment (and reduce interactions with wildlife). When followed, this approach has led to considerable increases in the cost of the HSR projects. The Central Valley in California and two ends of the proposed HSR line in the north and south of California present similar issues with delicate environments that the HSR tracks may affect, and highly urbanized areas with limited surface rights-of-way for the new HSR line. When finalizing the design solutions for the line, it will be important to consider how to protect the environment and what infrastructure will be required to minimize environmental impacts, as well as how to cross urban areas while minimizing barrier effects created by tracks running across urban neighborhoods. The negative barrier effect that the rail tracks create can cause greater disconnections between neighborhoods and lead to potential (or increase, if already present) marginalization of certain communities and exacerbation of inequality among urban residents. Various urban treatments should be considered to minimize the barrier effect, particularly if the tracks impact the access to urban activities and services for certain areas. Opportunities to revitalize activities around and inside HSR stations will also be possible, for example, the largely underutilized, to date, San Francisco Transbay Transit Terminal.

Peripheral HSR stations located in the outskirts of an urban area, on average, tend to perform more poorly in European countries, both in terms of ridership and capacity to attract economic and land use development. Still, if carefully coordinated with local planning and policy, non-central HSR stations have led to successful development and growth of local activities, as shown in the case study of Zaragoza, where the HSR station was not located in the city center but rather in an area with good potential for urban development. This can also happen in some California station-cities that build HSR stations in more peripheral city areas. For such examples, connecting the station to other parts of the city and region will be particularly important.

Providing appropriate connections to peripheral HSR stations with public transportation feeder lines and coordinating and planning for development surrounding the station seems to be essential to promote local development and access by non-vehicular modes. While many differences exist between Europe and the United

States, it seems likely that, especially in the U.S., which already features higher levels of car dependence, peripheral HSR stations will rely to a higher extent on driving as an access/egress mode. Further, the ability to generate economic development in areas around the station might remain uncertain, even if proper coordination with local planning agencies, businesses and developers spurs economic activity and redevelopment opportunities, in particular in regions such as California that are more used to low-density car-oriented developments. This development model might substantially affect the design and accessibility of station surroundings, due to the greater need for parking usually associated with car-oriented developments, limiting HSR's benefits in accessibility and capacity to serve passengers.

Feeder transportation services are important, in order to expand HSR's catchment area and increase opportunities for access to and egress from the station, including public transportation, active modes such as walking and bicycling, and new mobility solutions such as (shared) e-bikes and/or e-scooters, which can extend the access/egress distances beyond what is possible by walking or bicycling.

To a certain extent, HSR stations could operate in a rather different way in California, as its transportation system is characterized by much higher levels of car dependence and low-density development, and the power of the central core of most cities generate or attract economic activity is considerably smaller. Further, even when public transportation is present, and new investments are made, it is often designed mainly with car access, rather than pedestrian access, due to the local characteristics of land use and the dominant urban form.

The differences in the economic structure, land use patterns and transportation systems in California versus Europe might also mean that the impacts of HSR (and the way they might manifest themselves over time) might differ from what is observed in the summarized case studies from Europe, for example making non-central stations and car-access to HSR more popular choices in low-density environments of the Central Valley of California, assuming that connections by HSR are available to strong attractors (e.g., downtown San Francisco), where accessibility by public transit and walking is higher. As access by private car usually works well on one extreme of trips, which is different from what is observed in many case studies in Europe, where HSR mainly functions as a city-to-city connection. HSR in California could open opportunities to avoid car travel on highly congested freeways, and improve access to the central core of the largest cities from lower-density areas that currently experience very high traffic flows, for example, towards downtown San Francisco. Car-oriented facilities, including appropriate car parking adjacent to HSR stations, and innovative mobility solutions, including the creation and coordination of mobility hubs, would ensure proper access to HSR stations, while trip ends in San Francisco can be more easily handled through connections to mass transit services with some contribution from shared mobility services, where needed.

Another important conclusion that can be drawn from the European HSR experiences is that isolated HSR corridors put in operation without being properly connected to larger rail networks usually return results that are below expectations, both in terms of ridership and ability to spur economic and urban development. This was an important limiting factor in the case study of the Galicia corridor in Spain, and more generally in the findings from the literature all over Europe (for example, for the initial HSR corridor that was put in operation in Italy). This is similar to the development of the first segment of the California HSR corridor, which will

remain for the first years of operation not properly connected to the major metropolitan centers of San Francisco, San Jose or Los Angeles. If the lessons learned from Europe can be applied to California, initial impacts of the California HSR on the regions surrounding the first segment of the corridor will likely be modest until this segment connects to the large metropolitan centers of Northern and Southern California.[5]

Last but not least, the equity concerns raised in HSR contexts abroad are useful to inform policy making in California about potential equity issues associated with HSR deployment. These can be summarized in three areas: (1) the service might primarily benefit higher-earning households and high-income commuters, (2) potential gentrification effects in the areas around the stations, and (3) the negative impacts of HSR construction on traffic, noise, pollution, land value, etc. that might unequally affect lower-income households and members of marginalized communities. All these effects should be the object of appropriate studies and plans for mitigation through the policy making process.

[5] Additional headwinds with the operation of the HSR service on the initial segment in the Central Valley of California relate to the limited origin-destination flows of the smaller cities that are first served on this segment, and their relatively low-density and car-oriented land use, which might favor the use of cars over short/medium distances, also due to the need to have a vehicle at destination when using any of the stations served by the line to reach the final destination of a trip.

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