Cuadernos de Turismo, nº 57, (2026); pp. 255-279
eISSN: 1989-4635
DOI: https://doi.org/10.6018/turismo.711291
Universidad de Murcia

HIGH-SPEED RAIL AND TOURISM MOBILITY: IMPACTS OF RAILWAY LIBERALISATION ON AIR TRANSPORT AND ADOLFO SUÁREZ MADRID-BARAJAS AIRPORT

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ABSTRACT

This article analyses the effects of high-speed rail liberalisation in Spain on tourism mobility, territorial accessibility, and the operational dynamics of Adolfo Suárez Madrid-Barajas Airport which concentrates the majority of long-haul arrivals to Spain and acts as the country's main gateway for intercontinental tourism. Based on a methodology that combines a literature review, comparative analysis, and quantitative data processing, the study identifies a progressive modal shift from air to rail on medium-distance corridors and the loss of feeder flights at this airport. The findings highlight the need to advance towards a more integrated, efficient, and sustainable transport model that enhances long-haul connectivity, strengthens the international positioning of the Spanish tourism system, and fosters territorial cohesion.

Keywords: high-speed rail; liberalisation, intermodality; tourism mobility; air transport; intercontinental connectivity; Madrid-Barajas; territorial accessibility.

Fecha de recepción: 5 de mayo de 2025.
Fecha de aceptación: 29 de septiembre de 2025.
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Alta velocidad ferroviaria y movilidad turística: impactos de la liberalización ferroviaria sobre el transporte aéreo y el aeropuerto Adolfo Suárez Madrid-Barajas

RESUMEN

Este artículo analiza los efectos de la liberalización de la alta velocidad ferroviaria en España sobre la movilidad turística, la accesibilidad territorial y las dinámicas operativas del aeropuerto Adolfo Suárez Madrid-Barajas, que concentra la mayoría de las llegadas de largo recorrido al país y actúa como principal puerta de entrada del turismo intercontinental. A partir de una metodología que combina revisión bibliográfica, análisis comparativo y tratamiento de datos cuantitativos, el estudio identifica un progresivo cambio modal del avión al tren en los corredores de media distancia, así como la pérdida de vuelos de conexión (feeder) en este aeropuerto. Los resultados ponen de relieve la necesidad de avanzar hacia un modelo de transporte más integrado, eficiente y sostenible, que refuerce la conectividad de largo alcance, el posicionamiento internacional del sistema turístico español y la cohesión territorial.

Palabras clave: alta velocidad ferroviaria; liberalización, intermodalidad; movilidad turística; transporte aéreo; conectividad intercontinental; Madrid-Barajas; accesibilidad territorial.

1. INTRODUCTION

In recent decades, mobility has become one of the fundamental pillars underpinning tourism activity (Urry, 2016). The ability to travel efficiently, rapidly, and affordably between different territories has profoundly transformed the ways destinations are consumed, altering both tourist flows and the requirements that territories must meet to remain competitive (Cresswell, 2014).

In this context, transport systems play a strategic role not only as supporting infrastructures but also as constitutive elements of the tourism product itself, capable of influencing the spatial distribution of demand, the perception of travel, and the competitiveness of territories (Pellegrino, 2021). Although phenomena such as digitalisation and climate change now occupy a central place in the global tourism agenda, the role of transport infrastructures, and particularly their degree of intermodal articulation, remains decisive in shaping the international tourism system (UNWTO, 2023).

In Europe, the development of a multimodal transport network has become one of the European Union's top policy priorities (European Commission, 2021). The deployment of high-speed rail (HSR) networks has brought about a genuine revolution in the conception of space, reducing travel times, enhancing accessibility, and fostering new, more sustainable forms of mobility (Vickerman, 2016). Since its expansion in the 1990s, HSR has evolved from a technological symbol to a structural axis of cohesion and territorial development policy, while also becoming an attractive transport mode for urban, cultural, and short-break tourism (Vickerman, 2018).

Its potential to connect dense metropolitan areas, facilitate intra-regional travel, and contribute to emission reductions has been widely recognised (Vrána *et al*., 2023). However, its implementation has been neither homogeneous nor free from tensions. National models differ substantially in terms of territorial coverage, degree of intermodal integration, and the extent of market liberalisation (UIC, 2020).

Spain constitutes a particularly distinctive case. With a high-speed rail network exceeding 3,700 kilometres, it is the country with the longest HSR network in Europe and one of the most committed to using this model as a tool for territorial cohesion, regional development, and the enhancement of connectivity between medium-sized and large cities (Albalate and Fageda, 2016). Since the inauguration of the Madrid–Seville AVE line in 1992, the network's development has followed an eminently radial pattern centred on the national capital, driven by successive infrastructure plans and largely funded by European Union cohesion funds. This approach has had direct effects on tourism: numerous heritage, cultural, and coastal cities (such as Valencia, Málaga, Seville, Córdoba, and Alicante) have experienced improvements in accessibility; Yet many of these destinations were already well-established tourist hubs before the arrival of high-speed rail, which points more to a reinforcing effect than to a genuinely generative one (Monzon *et al*., 2021).

Nonetheless, the Spanish model also presents significant limitations, including pronounced centralisation, limited transversal connectivity, and weak functional integration with the airport system (Fageda and Olivieri, 2019). This last point is especially critical in the case of Adolfo Suárez Madrid-Barajas Airport, which concentrates the majority of long-haul arrivals to Spain and acts as the country's main gateway for intercontinental tourism. According to data from AENA (2024) and INE-FRONTUR (2024), the airport handled 3.03 million passengers from the United States in 2023, compared to 1.56 million at Barcelona-El Prat and just 0.17 million at Málaga-Costa del Sol. This overwhelming dominance in non-European connectivity, particularly with North America, Latin America, and East Asia, confirms its strategic relevance as a case study to examine the challenges and opportunities of rail–air intermodality in a liberalised transport context.

The situation has become even more complex with the advent of rail liberalisation promoted by the European Union. Since late 2020, Spain has opened its passenger rail market to competition, allowing new operators to enter major HSR corridors. This measure, aligned with the principles of the European single market, aims to promote efficiency, lower prices, and improve service quality. Although it is a recent phenomenon, the first effects are already evident: increased train frequency, reduced fares, and significant passenger growth on key routes such as Madrid–Barcelona, Madrid–Valencia, and Madrid–Málaga (CNMC, 2024).

From a tourism perspective, these changes are directly influencing how destinations are accessed. The train is capturing a growing share of the market from air travel on journeys between 200 and 600 kilometres, traditionally served by short-haul domestic flights. This modal shift has significant implications for the system's sustainability as well as for the operational dynamics of Madrid-Barajas Airport. In particular, the reduction or disappearance of short-haul feeder flights threatens the airport's role as an intermodal platform for intercontinental tourists arriving from distant markets. If this trend continues

without the development of alternative connectivity mechanisms, it could erode the hub's intercontinental competitiveness.

Thus, the issues addressed by this research are not merely technical but strategic: How does rail liberalisation affect the tourism transport system in Spain? What consequences does it have for destination connectivity and the functioning of air hubs? Can rail become an ally of air transport through well-planned intermodality? Or are we witnessing a process that fragments the system rather than integrating it?

This article tackles these questions from a critical and interdisciplinary perspective. Its objective is to analyse the effects of high-speed rail liberalisation on tourism in Spain, with particular attention to its impact on air transport and the Adolfo Suárez Madrid-Barajas airport hub, considering mobility as an essential component of the tourism system. Using a methodology based on scientific literature review, comparative analysis of international experiences, and statistical data from national and international official sources, it examines the reconfiguration of tourist flows, the transformation of the modal system, and the challenges posed by integrating transport modes in a context of growing competition.

The article is structured into six sections. Following this introduction, the second provides a detailed overview of the Spanish high-speed rail system and its role in shaping tourism accessibility. The third analyses the liberalisation process in the rail market and its effects on intermodal mobility and tourist demand. The fourth section focuses on Madrid-Barajas Airport, evaluating the consequences of modal change on its functionality as a tourism hub. Subsequently, a critical discussion is developed on the challenges of intermodal planning and the role of transport in tourism competitiveness, before concluding with key findings and proposing action lines towards a more integrated, balanced, and sustainable model.

2. HIGH-SPEED RAIL IN SPAIN: STRUCTURE, TERRITORIAL LOGIC AND TOURISM ACCESSIBILITY

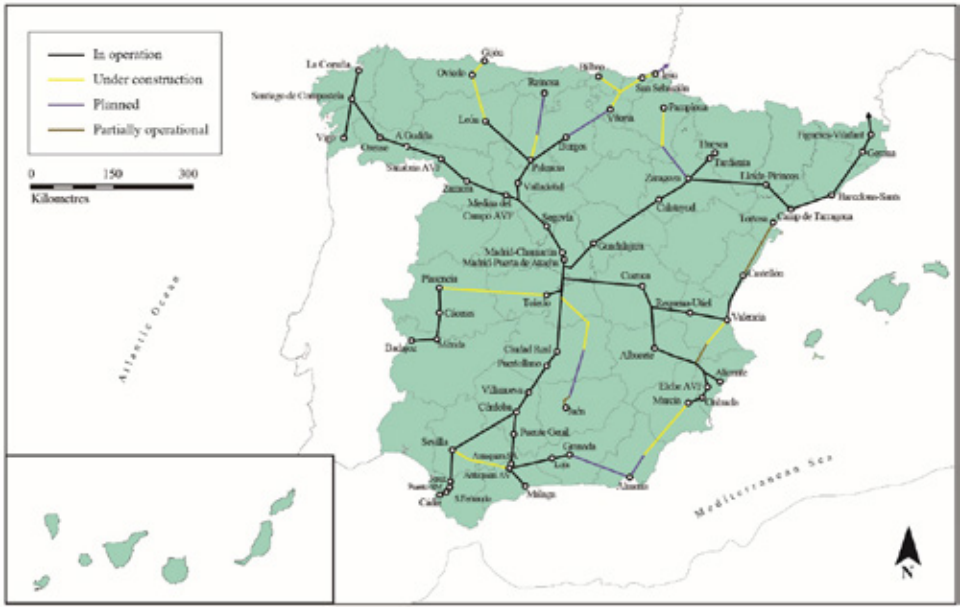
The development of high-speed rail (HSR) in Spain has constituted one of the most ambitious infrastructure investments in the European context (Albalate and León-Gómez, 2024). Since the inauguration of the Madrid–Seville line in 1992, coinciding with Seville's Universal Exposition, the HSR network has expanded steadily, positioning Spain as the European country with the longest operational high-speed network and the second worldwide, only behind China (UIC, 2020). This expansion, driven by sectoral transport planning, has had profound implications for the configuration of the national tourism space, the articulation of mobility flows, and the redefinition of accessibility as a competitive advantage for destinations (Albalate and Fageda, 2016).

Currently, the Spanish HSR system boasts more than 3,700 kilometres of operational track and 47 stations (Figure 1)[1]. Its logic, predominantly radial, inherits the nine-

1 From an operational perspective, the Spanish railway network is distinguished by its technological diversity and the coexistence of multiple service types and track gauges. Whereas high-speed rail (HSR) lines operate on the international UIC gauge (1,435 mm), the conventional network retains the Iberian gauge (1,668 mm). This duality has necessitated the development of gauge-changing rolling stock, such as the Alvia and Euromed services, thereby enabling the extension of high-speed services beyond the purpose-built HSR lines.

teenth-century railway pattern, with Madrid as the central node from which the main lines diverge towards the peninsular periphery. This configuration, supported by the Strategic Infrastructure and Transport Plan (PEIT, 2005–2023) and by European Union cohesion funds, has consolidated Madrid's role as the principal redistributor of flows, promoting centre–periphery journeys and fostering a functional restructuring of the national tourism space by expanding the spatial and temporal margins of travel and enabling new modalities of short-stay tourism consumption (Pagliara *et al*., 2015)[2].

Figure 1
HIGH-SPEED RAIL LINES IN SPAIN (2025)



Source: Own elaboration.

In this sense, cities such as Córdoba, Seville, Zaragoza, Valencia, Málaga, Valladolid, Alicante, and Girona, among others, have experienced significant reductions in travel times from Madrid and other major source cities, facilitating their integration into the principal national and international tourism circuits (Albalate *et al*., 2017). Many of these cities, however, already had strong tourism profiles prior to the arrival of high-speed rail,

2 There is broad scholarly consensus that high-speed rail, alongside air transport, has profoundly transformed not only patterns of production and human interaction, but also the conceptualisation of the planet itself (Rodrigue, 2021). In this context, both modes are considered instrumental in shaping a new relationship between humans and tourism space, articulated through concepts such as "space-time convergence" (Janelle, 1969), "plasticity" (Forer, 1978), and "space-time compression" (Harvey, 1983), whereby traditional Euclidean distances are supplanted by functional distances, perceived in terms of connections, frequencies, and travel times (Díez-Pisonero, 2016).

thanks to their coastal location, historical heritage, or institutional functions, suggesting that HSR has amplified rather than initiated their tourism appeal. Building on these pre-existing assets, they have benefited from the rise in short-term visitors, particularly those attracted by urban getaways, event-driven travel (such as congresses, fairs, and festivals), or themed journeys. This improved connectivity has invigorated both leisure and business tourism, contributing to the territorial capillarity of the tourism offer, diversifying demand, and, in some cases, helping to reduce seasonality (Vrána *et al*., 2023).

A paradigmatic example of this process is the Madrid–Seville–Málaga axis, which has consolidated the so-called "cultural triangle" of southern Spain as a leading urban destination (Sánchez-Cubo *et al*., 2021). Also noteworthy is the case of the Mediterranean Corridor, where HSR has boosted the tourism dynamism of cities such as Valencia and Alicante, which had traditionally relied on air transport (Boira and Berzi, 2023). At an international level, HSR has facilitated access from France to northern and eastern Spanish destinations through the rail connections at Figueres, Girona, and Barcelona, thus expanding the European tourism market accessible by train (Masson and Petiot, 2009).

Moreover, numerous intermediate cities have become functionally integrated into the orbit of major metropolises, with travel times of under 80 minutes, fostering processes of "discontinuous metropolitanisation" (Bellet, 2013). Although initially linked to labour commuting dynamics, these processes have also led to a significant increase in national tourist flows. This is the case for Toledo, Segovia, Valladolid, Ciudad Real, Puertollano, and Guadalajara in relation to Madrid; or Camp de Tarragona, Lleida, and Girona in relation to Barcelona (Martín *et al*., 2021).

One of the distinctive features of the Spanish model lies in the fact that, unlike other European countries such as France, Germany, or Italy, HSR has not been conceived solely as a tool for linking major metropolises but also as an instrument for territorial structuring, regional rebalancing, and internal cohesion (Aparicio, 2021). This approach, partly motivated by political pressures and the need to justify public investment, has had significant consequences for the configuration of tourism flows and the competitive positioning of many traditionally peripheral or economically less dynamic destinations. However, the impact has not been uniformed across the network. While cities such as Puertollano, Ciudad Real, Huesca, Segovia, Zamora, or Lleida have been integrated into the HSR system, the outcomes in terms of passenger volumes, profitability, and tourism development have varied widely (Albalate *et al*., 2017), often hindered by the absence of complementary tourism policies or sufficient baseline demand.

Additionally, HSR has reinforced Madrid's role as a flow redistribution platform. The capital not only concentrates a large share of origin and destination movements but also acts as a linking point between different corridors. This centralised logic has consolidated its position within the national tourism system but has also exacerbated radial dependence and limited transversal connectivity, hindering the development of multicentric itineraries or non-radial thematic circuits (Pagliara *et al*., 2015). From this perspective, the Spanish model presents a clear duality: on the one hand, it significantly improves centre–periphery connectivity; on the other, it reproduces spatial inequalities between corridors and excludes large parts of the interior and north-western regions from the HSR system (Aparicio, 2021).

Despite its achievements, the Spanish HSR system exhibits important shortcomings from a tourism perspective. One of the most notable is the lack of effective intermodal articulation with the airport system, as most airports lack direct connections with the high-speed network. This disconnection limits the potential for developing combined tourism itineraries, reducing door-to-door travel times, and leveraging synergies between rail and air transport (Gundelfinger and Coto, 2017), especially critical in the case of Adolfo Suárez Madrid-Barajas Airport, whose intercontinental hub function is not yet matched by seamless national rail integration.

Moreover, the excessive centralisation of the system reinforces the hierarchy of destinations, increasing demand concentration in the most dynamic corridors and aggravating territorial disparities (Fageda and Olivieri, 2019). The capacity to attract visitors is determined not only by territorial factors but also by infrastructural ones: whether or not a destination belongs to the HSR network (Martin *et al*., 2021). Thus, the train becomes a factor of competitiveness but also a mechanism of relative exclusion for territories that remain disconnected.

Finally, the symbolic dimension of high-speed rail must be highlighted, as it is increasingly perceived as an indicator of modernity, efficiency, and environmental commitment (Shen *et al*., 2023). In a context of growing concern for sustainability, the use of trains over planes reinforces the image of destinations committed to the ecological transition. This symbolic attribute, although difficult to quantify, is gaining considerable weight in contemporary tourism narratives (Henríquez and Deakin, 2017).

In summary, the Spanish HSR network has contributed to transforming the national tourism geography, expanding accessibility, diversifying demand, and redefining spatial relationships between cities. However, for this infrastructure to fully deploy its potential in supporting sustainable and inclusive tourism, it will be necessary to move towards a more polycentric, intermodal, and strategic planning approach, overcoming modal competition and prioritising functional cooperation between networks. Rail liberalisation introduces new dynamics that may enhance, correct, or deepen these trends. The analysis of these effects will be the subject of the following section.

3. THE LIBERALISATION OF RAIL TRANSPORT IN EUROPE AND SPAIN: STRUCTURAL EFFECTS ON TOURIST MOBILITY

The liberalisation of rail transport in Europe has been one of the most complex and prolonged regulatory processes within the framework of the European Union's common transport policy. Unlike other sectors liberalised in previous decades, such as aviation, energy, or telecommunications, the railway system exhibited structural characteristics that complicated its opening: strong vertical integration between infrastructure and services, high fixed costs, low operational flexibility, and a management model historically based on state monopolies (Campos, 2023). Nevertheless, the European Commission deemed it essential to include railways in the transport modernisation agenda and, since the late 1990s, has undertaken a series of reforms aimed at creating a Single European Railway Area (Solina and Abramović, 2022).

The process was structured around four major "railway packages", which progressively introduced the separation of infrastructure management and service operation, technical harmonisation of networks, open access for new operators, and the liberalisation, first of freight transport and subsequently of passenger transport (Campos, 2023). These reforms sought to improve system efficiency, enhance service quality, lower prices, and foster innovation, especially in the case of tourism mobility and short-stay consumption models (Lerida and Nombela, 2022).

The implementation of these directives has varied among Member States, both in terms of timing and outcomes. To understand Spain's position within the European context, a comparison with other countries that have undergone the same process is proposed, highlighting the effects on competition, prices, intermodal integration, and tourism impact. Table 1 illustrates the diversity of national strategies and their outcomes in terms of liberalisation and tourism relevance.

Some countries, such as the United Kingdom or Sweden, began the liberalisation process early with a comprehensive approach, while others, such as France and Germany, adopted a more gradual method, encountering greater resistance from historic operators (Solina and Abramović, 2022). Italy, however, has emerged as the paradigmatic success story: following the entry of Italo (NTV) in 2012, the rail market experienced a nearly 40% reduction in prices, a notable increase in frequencies, and sustained demand growth (Beria and Grimaldi, 2017).

In Spain, the railway sector has traditionally been closely linked to state intervention through Renfe, the public company that integrated both operation and infrastructure management. However, the liberalisation process necessitated the vertical separation of operation (Renfe) and infrastructure management (Adif), in compliance with EU regulations (Lerida and Nombela, 2022). Although freight transport was liberalised as early as 2005, the opening of passenger services materialised only at the end of 2020, when the first railway capacity packages were awarded to new operators on major HSR corridors: Madrid–Barcelona, Madrid–Valencia–Alicante, and Madrid–Seville–Málaga (CNMC, 2024).

This shift towards greater diversification has significantly impacted the spatial and economic accessibility of key tourism destinations (Campos, 2023). The Spanish system ceased to be monopolised solely by AVE as the flagship product, Alvia and Euromed services (which combine HSR and conventional lines), and Avant trains for medium-distance travel. The entry of Ouigo (a SNCF subsidiary) in 2021, followed by Iryo (a consortium between Trenitalia and Air Nostrum) in 2022, along with Renfe's launch of Avlo (a low-cost train), has created unprecedented commercial diversification, directly impacting the connectivity of national tourist destinations (Table 2).

Table 1
INTERNATIONAL COMPARISON OF THE RAIL LIBERALISATION PROCESS AND ITS TOURISM IMPACT

Country	HSR Operators (historic and private)	Start of Passenger Liberalisation	HSR Length (km)	Level of Competition	Main Effects	Intermodal Integration	Estimated Tourism Impact
United Kingdom	Network Rail (infra.) / Avanti West Coast, LNER, GWR	1994 (full privatisation, limited HSR)	113 (HS1)	Low	High competition but criticised lack of integration	High (London–Heathrow, Gatwick)	No substantial HSR network. High internal tourism use.
Sweden	SJ (historic) / Snälltåget, MTRX	1992	150	Medium-low	Liberalised market for decades. High domestic and regional tourism use.	Moderate (Stockholm–Arlanda rail link)	High domestic tourism connectivity, limited international influence
Italy	Trenitalia (historic) / Italo (NTV)	2012 (Italo entry)	1300	Very high	Price drop (–40%), increased frequencies, higher demand	High (especially Rome–Fiumicino)	High connectivity between key tourist destinations (Rome, Florence, Venice, Naples). High HSR use by tourists.
France	SNCF (historic) / Trenitalia France, Renfe (Ouigo Spain)	2021 (effective in HSR)	2734	Moderate	Limited impact so far	Partial (only Paris–CDG)	Cultural tourism reinforced. Start of market opening. High Paris–province concentration.
Germany	Deutsche Bahn (historic) / FlixTrain (very limited)	Ongoing	1610	Low	Limited real competition	Medium (Frankfurt, Munich)	Low liberalisation effect. Good connectivity but dominated by DB.
Spain	Renfe (historic) / Ouigo, Iryo, Avlo (Renfe low cost)	2020 (effective from 2021)	3774	High	Price drop, increased passengers, more frequencies	Weak (except future link to Barajas)	Fare reductions, frequency increases, strong modal shift in tourist corridors. Significant boost to domestic tourist demand.

Source: Own elaboration based on ECMT (2024), UIC (2020), CNMC (2023, 2024), national operators and sectoral analysis.

Table 2
MAIN HSR OPERATORS IN SPAIN, COVERED CORRIDORS, FREQUENCY AND COMPETITIVE POSITIONING (2024)

Operator	Start Year	Main Corridors	Daily Frequency (approx.)	Commercial Positioning	Main Train Used	Maximum Speed
Renfe (AVE)	1992	Madrid–Barcelona, Madrid–Valencia, Madrid–Seville/Málaga	20–25 per direction	Premium service, flexible fares, first class and tourist plus	S-100, S-102, S-112, S-103	300 km/h
Renfe (Avlo)	2021	Madrid–Barcelona, Madrid–Valencia, Madrid–Seville/Málaga, Madrid–Alicante	6–8 per direction	Low cost, no extras, youth and tourism orientation	Adapted S-112 Avlo	300 km/h
Ouigo España	2021	Madrid–Barcelona, Madrid–Valencia, (Madrid–Alicante in 2024)	6–9 per direction	Low cost, prices from €9, family and tourism focus	Alstom Euroduplex	300 km/h
Iryo	2022	Madrid–Barcelona, Madrid–Valencia, Madrid–Seville/Málaga	6–10 per direction	Accessible business service, high quality, corporate and tourism orientation	Frecciarossa ETR1000	360 km/h (limited to 300 km/h in Spain)

Source: Own elaboration based on Renfe, Ouigo, Iryo, Adif and CNMC (2023–2024).

This rail transformation has led to a historic increase in high-speed rail users in Spain. According to the National Commission on Markets and Competition (CNMC, 2024), a record-breaking 31.7 million passengers used high-speed rail in 2023, representing a 35% annual increase and clearly exceeding pre-pandemic figures. This exceptional growth contrasts with the evolution of domestic air transport, which also showed signs of recovery—17.15 million air passengers were recorded in 2023, a 15% increase compared to 2022 and nearly matching the 2019 figure (17.06 million). However, this recovery in absolute terms is overshadowed by a marked decline in market share on several key corridors where high-speed rail now holds clear dominance.

Particularly on routes such as Madrid–Barcelona, Madrid–Valencia, and Madrid–Seville/Málaga, a significant modal shift has occurred, driven by fare reductions of 25% to 50%, a more than 40% increase in daily frequencies, and improvements in travel time and service regularity. These dynamics reflect both the capture of former air passengers and the generation of new demand, especially within the leisure and tourism sectors, consolidating rail as the preferred mode of transport on medium-distance domestic routes.

From a tourism perspective, these changes represent a structural opportunity. Firstly, liberalisation widens access for previously excluded socioeconomic segments, promoting more inclusive mobility. Secondly, it enables the development of flexible, multimodal, and sustainable tourism products adapted to short stays and urban getaways. For instance, travellers can now plan round trips to Valencia or Málaga for under €30, avoiding delays and security formalities associated with air travel. This strengthens rail's position as a central pillar of short-distance tourism.

However, this rail revolution also poses risks. Its efficiency as a low-emission feeder to major airports is contingent upon true intermodal integration (Gundelfinger and Coto, 2017). The absence of direct HSR links to terminals may discourage combined journeys, particularly among international tourists who value simplicity and speed (Albalate *et al*., 2017). This is a critical issue for Madrid–Barajas, where the lack of a dedicated HSR terminal reduces its efficiency as an intermodal hub. This spatial mismatch is illustrated in the next section with a location map of Madrid–Barajas Airport and the city's main high-speed rail stations.

Furthermore, liberalisation may have differentiated territorial effects. While core corridors experience clear gains, secondary or disconnected destinations may suffer in terms of tourist flows and international visibility (Albalate and Fageda, 2016). Without strategic multimodal coordination, liberalisation risks reinforcing rather than correcting territorial asymmetries.

From an environmental perspective, the modal shift from short-haul flights to high-speed rail is aligned with the decarbonisation objectives of the European Green Deal (Ney, 2023). Yet recent scholarship warns of the unintended territorial costs associated with HSR development such as landscape fragmentation, urban sprawl, and socio-economic polarisation (Martin *et al*., 2021; Shen *et al*., 2023). Only through integrated territorial planning can the environmental benefits of modal shift be preserved and socio-spatial disparities minimised.

In short, while high-speed rail has emerged as a key pillar of national tourism mobility, its long-term effectiveness depends on achieving full intermodal integration in strategic

hubs. Madrid–Barajas Airport exemplifies this challenge, as the lack of direct rail access undermines its role as a seamless air–rail gateway, a key issue explored in the next section.

4. MADRID–BARAJAS ADOLFO SUÁREZ AIRPORT IN THE CONTEXT OF HIGH-SPEED RAIL GROWTH: INTERMODAL CHALLENGES AND THE RECONFIGURATION OF TOURISM MOBILITY

Adolfo Suárez Madrid–Barajas Airport represents Spain's principal gateway to the world and one of the most important intercontinental hubs in Southern Europe. This dual role has positioned it as a key node in the territorial articulation of tourism flows, channelling the arrival of millions of tourists annually and serving as a redistribution platform to other national and international destinations (Díez-Pisonero, 2019). Located just 12 kilometres from the city centre, its proximity to the urban core enhances its relevance within Spain's tourism system, offering travellers efficiency, speed, and cost-effective transfers (Pulido, 2006).

This infrastructure plays a central role in both the Madrid region and the broader Spanish economy. It stimulates regional business activity, supports tourism development, and currently contributes approximately 10% of the Madrid region's GDP (MTMS, 2023), while generating more than 305,000 jobs, almost 20% of them within the city itself. Its strategic importance is further strengthened by its function as the main hub for Iberia Airlines and its international prominence as the capital city's airport (Díez-Pisonero, 2019).

Managed by Aena, Madrid–Barajas leads the Spanish airport network in passenger volume, cargo, and operations, while also holding a prominent European position: it ranked as the fifth busiest airport in Europe and fifteenth globally in 2023, with 66.2 million passengers (ACI Europe, 2024). A key comparative advantage lies in its specialisation in transatlantic connectivity, particularly with Latin America. Around 30% of passengers are in transit, and 26% of them travel on Latin American routes (ABC World Airways Guide, 2024). Plans are underway to expand these markets toward Asia-Pacific, targeting long-haul tourism source countries such as India and South Korea (UNWTO, 2024).

This leadership has been supported by several strategic developments. First, Iberia's integration into the IAG group in 2008 (alongside British Airways and Vueling) allowed it to restructure and regain profitability. Second, the 2006 opening of Terminal 4 (T4) and its satellite building (T4S) significantly expanded the airport's operational capacity to 70 million passengers and 120 movements per hour (Aena, 2015). In parallel, broader factors such as Spain's consolidation as a global tourism power and Madrid's emergence as an economic hub have further enhanced the airport's centrality.

Anticipating continued growth in air traffic, Aena has launched two major development plans. The first, still under evaluation, involves the possible construction of a new airport for Madrid, potentially at the Casarrubios aerodrome in Toledo, about 30 kilometres from the capital (Barroso, 2024). The second, already approved in 2023, is a €2.4 billion expansion of Madrid–Barajas. This plan includes the integration and renovation of Terminals 1, 2, and 3, the construction of a new central processing building, and the enlargement of T4 and T4S. These changes aim to raise the airport's GDP contribution from 9.3% to 12%

(MTMS, 2023) and increase its passenger capacity to 90 million annually. The plan also incorporates the development of the new Barajas Airport City (AENA, 2024b).

Despite this upward trajectory, Madrid–Barajas faces an emerging structural challenge: the rapid expansion of high-speed rail (HSR), driven by liberalisation and the entry of new operators, is transforming domestic mobility patterns in Spain. A profound modal shift from air to rail is underway, particularly along key centre–periphery corridors that connect Madrid with major cities across Spain, including those in the Mediterranean, southern, and northern regions (Gundelfinger and Coto, 2017). On the main inland routes, AVE services now account for more than 75% of passenger traffic, a share that is even higher in certain cases (CNMC, 2024).

As shown in Table 3, this shift is especially pronounced on routes such as Madrid–Valencia, Madrid–Seville, and Madrid–Barcelona, which were once densely served by air but now operate with sharply reduced flight frequencies. This reconfiguration has positioned HSR as the primary feeder of domestic tourist mobility, while air connectivity has become increasingly focused on long-haul international flows.

Table 3
HIGH-SPEED RAIL (HSR) CENTRE–PERIPHERY CORRIDORS, CONNECTED TOURIST DESTINATIONS, AND EFFECTS ON AIR CONNECTIVITY AT MADRID-BARAJAS AIRPORT (2024)

Corridor	HSR Share (%)	Air Share (%)	Train Time (minutes)	Air Time + Transfers (minutes)*	Connected Tourist Destinations	Impact on Air and Tourism Connectivity
Madrid–Barcelona	78.30%	21.70%	149	180–200	Barcelona, Tarragona, Sitges, Costa Brava	Elimination of over 15 daily air frequencies. The Madrid-Barcelona air shuttle has lost 45% of its passengers since 2019, falling from 4.3 to 2.4 million annual users. Barcelona-El Prat is reconfiguring its national connections. HSR increases role in both business and leisure travel.
Madrid–Valencia	89.90%	10.10%	109	165–180	Valencia, Albufera, Gandía, Cullera	Almost complete elimination of regular flights. In 2023, only one symbolic daily flight remained for international connections. HSR connection prioritised with potential feeder role if intermodality is developed.

Corridor	HSR Share (%)	Air Share (%)	Train Time (minutes)	Air Time + Transfers (minutes)*	Connected Tourist Destinations	Impact on Air and Tourism Connectivity
Madrid–Alicante	76.50%	23.50%	140	180–210	Alicante, Benidorm, Elche, Santa Pola	70% reduction in point-to-point flights. Over 30% increase in tourist arrivals by HSR since 2021. Strong seasonality persists in air demand. Rail sustains tourism connection.
Madrid–Málaga	75.20%	24.80%	175	200–220	Málaga, Marbella, Ronda, Costa del Sol	Disappearance of regular direct flights except for some seasonal connections. HSR covers national tourism flows during weekends and peak seasons with high occupancy rates. Málaga Airport concentrates 60% of its traffic on international flights.
Madrid–Seville	80.10%	19.90%	175	195–215	Seville, Córdoba, Jerez de la Frontera, Cádiz	70% drop in direct flights from Madrid. High substitution by HSR. More than 85% reduction in flight frequencies with Madrid by 2022. Potential impact on international tourist flows requiring connections. Seville now prioritises HSR for cultural and MICE tourism.
Madrid–Zaragoza	>85%*	<15%	75	170–190	Zaragoza, Huesca, Aragonese Pyrenees	Practical disappearance of air link. HSR absorbs tourist and business demand. Strong potential for combined tickets. Zaragoza Airport limited to charter and low-cost international flights.

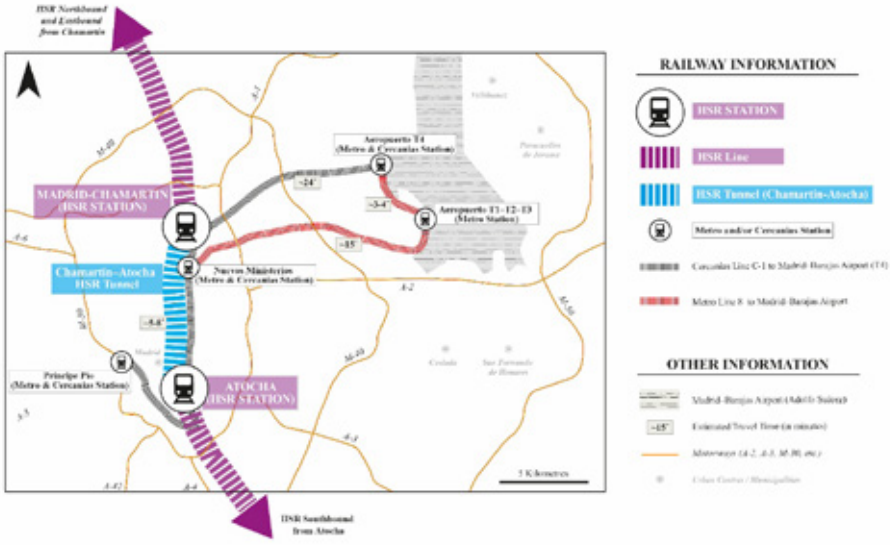
Note: Estimated based on HSR occupancy and service frequency.
Source: Author's own elaboration based on CNMC (2023, 2024), Renfe, Aena, tourism operators, and booking platforms.

Although this shift contributes positively to sustainability and modal efficiency, it creates operational challenges for Madrid–Barajas Airport, as many international passengers still require domestic connections. The absence of a dedicated high-speed rail (HSR)

station at the airport aggravates this issue. While Madrid has two main HSR stations (Chamartín, in the north, and Atocha, in the south) neither is directly linked to the airport terminals, which forces travellers to undertake time-consuming urban transfers.

Figure 2 illustrates this spatial mismatch and provides a detailed overview of the current intermodal configuration. The two HSR stations are now interconnected via a high-speed underground tunnel, inaugurated in 2022, which enables trains to traverse the city in approximately 5 to 8 minutes. However, connecting either station with the airport still requires additional transit steps. From Chamartín, travellers can reach Terminal 4 of Madrid–Barajas in around 24 minutes using the Cercanías commuter rail service (Line C-1). Alternatively, the Metro Line 8, departing from Nuevos Ministerios, provides access to Terminals 1, 2 and 3 in about 15 minutes, and to Terminal 4 with an additional 3–4 minutes of travel. While these options are functional, they lack the simplicity and integration expected from a fully intermodal hub, particularly for international passengers unfamiliar with the local transport system.

Figure 2
LOCATION MAP OF MADRID–BARAJAS AIRPORT IN RELATION TO ATOCHA AND CHAMARTÍN STATIONS, WITH URBAN TRANSFER ROUTES AND INDICATIVE TRAVEL TIMES



Source: Own elaboration.

To further illustrate the implications of this disconnection, Table 4 simulates travel times from several Spanish cities to long-haul destinations via Madrid, comparing current transfer conditions with a hypothetical scenario of direct HSR access at Barajas. The results show potential time savings of 85–100 minutes, improving the airport's competitiveness and user experience.

Table 4

ESTIMATED TOTAL TRAIN–AIR CONNECTION TIME FROM SPANISH CITIES TO INTERCONTINENTAL TOURIST DESTINATIONS VIA MADRID-BARAJAS (SCENARIO WITH AND WITHOUT INTERMODALITY; 2024)

Origin City (HSR)	Final Tourist Destination (via MAD)	Current Total Time (minutes)	Total Time with Intermodality (minutes)	Estimated Time Saving (minutes)	Associated Tourism Potential	Main Strategic Benefit
Seville	Cancún (via MAD)	530	430	100	Established sun-and-beach destination with high European tourist demand, especially during winter. High dependence on air connectivity and price sensitivity.	Reinforcement of competitive appeal against rival hubs (Lisbon, Paris) and diversification of outbound demand from Andalusia to Caribbean destinations.
Valencia	Buenos Aires (via MAD)	495	410	85	Large volume of cultural tourism and VFR (Visiting Friends and Relatives) traffic, with strong historical and community links between Spain and Argentina.	Reduction of logistical frictions in the intermodal transit, improved passenger experience, and increased loyalty of VFR and cultural segments.
Málaga	Toronto (via MAD)	525	435	90	Fast-growing long-haul destination with strong demand for cultural tourism, family travel, and academic mobility. No direct flights from southern Spain.	Enhances connectivity between southern Spain and North America; improves intermodal flows and strengthens Madrid as the national hub for transatlantic routes.
Alicante	Santiago de Chile (via MAD)	550	465	85	Long-haul destination for travellers interested in nature, adventure, and Latin American cultural tourism. Requires fluid and accessible connections to capture non-capital European markets.	Expansion of the South American tourist market from the Spanish Mediterranean coast, eliminating intermediate steps and increasing Barajas' connection appeal.
Zaragoza	Lima (via MAD)	505	420	85	Cultural and gastronomic capital of Peru, with strong appeal for European markets and growing experiential tourism demand. Efficient connectivity from intermediate cities can enhance high-value tourist flows.	Positioning Zaragoza as an effective HSR gateway for intercontinental connections, boosting its role as a regional HSR node linked to Latin America.

Note 1: Current total time includes HSR journey, urban transfer, airport waiting times, and flight connection; Note 2: The intermodality scenario assumes an HSR station at Barajas Airport, coordinated timetables, and combined ticketing.

Source: Author's own elaboration based on Renfe, Aena, Google Maps, and intermodality scenario simulations.

Complementing this outbound perspective, Table 5 presents a simulation from the inbound angle. It estimates the potential reduction in travel times for long-haul international tourists arriving at Madrid–Barajas who wish to reach secondary Spanish cities by rail. The figures suggest savings of 75–105 minutes with an integrated intermodal system.

Table 5
COMPARATIVE SIMULATION OF CURRENT AND PROJECTED TRAVEL TIMES FROM MADRID-BARAJAS AIRPORT TO SELECTED SPANISH CITIES FOR KEY HIGH-SPENDING TOURISM MARKETS (CANADA, SOUTH KOREA, INDIA, RUSSIA)

Origin Country	Arrival Airport	Destination City	Current Travel (Air + Transfer)	Projected Travel (Integrated HSR)
Canada	Madrid-Barajas	Granada	5h 30m (T4–Atocha–HSR)	3h 45m (direct rail from T4)
India	Madrid-Barajas	Valencia	3h 40m (T4–Atocha–HSR)	2h 20m (direct rail from T4)
South Korea	Madrid-Barajas	Córdoba	4h 55m (T4–Atocha–HSR)	3h 15m (direct rail from T4)
Russia	Madrid-Barajas	Sevilla	5h 10m (T4–Atocha–HSR)	3h 25m (direct rail from T4)

Sources: Own elaboration based on AENA (2024), RENFE (2024), Google Maps (2024), UNWTO (2024).

These improvements in time and convenience could significantly reinforce Madrid's role as a gateway to Spain's tourism system, particularly for high-spending travellers from long-haul markets. The ability to seamlessly redistribute passengers via HSR would position Barajas competitively alongside other European hubs. France and Germany already exemplify this trend: France's 2021 Climate Law banned short-haul flights with viable rail alternatives under 2.5 hours (Bonilla and Ivaldi, 2023), while Germany promotes intermodality through integrated ticketing between Deutsche Bahn and Lufthansa (Mindur and Mindur, 2022).

At the same time, the evolution of air travel in Spain reveals an increasingly fragmented landscape. The rise of low-cost carriers and the growing role of secondary airports have diverted large volumes of inbound leisure tourists from Madrid. These airports, with strong direct connections to northern Europe, often bypass the capital entirely (INE-FRONTUR, 2024). In fact, this same source indicates that Madrid–Barajas is not the main arrival point for Spain's top three tourist markets (UK, France, and Germany) who more frequently use airports in Barcelona or Málaga. By contrast, Barajas remains dominant for long-haul intercontinental arrivals, especially from the US, Canada, Latin America, and increasingly, Asia–Pacific. This duality must be acknowledged to avoid overgeneralising the airport's function in national tourism flows.

In conclusion, the strategic coordination between high-speed rail and long-haul air traffic is no longer a luxury, but a necessity for environmental, economic, and competitive reasons. A coherent intermodal policy at Madrid–Barajas would reduce travel times, improve connectivity across the territory, enhance the tourist experience, and align Spain with leading European infrastructure models. Only by fully integrating these systems can Madrid reinforce its status as a global hub for sustainable and inclusive tourism mobility.

5. DISCUSSION: LIBERALISATION, INTERMODALITY, AND TOURISM MOBILITY IN A TRANSITIONING TRANSPORT SYSTEM

This study has focused on the specific case of Madrid-Barajas Airport, not as a general gateway for international tourism, but as a strategic node for intercontinental arrivals. This focus responds to the fact that Barajas plays a leading role in long-haul tourism flows, especially from markets such as the United States, Canada, Latin America and East Asia, where other Spanish airports have limited connectivity (INE-FRONTUR, 2024; UNWTO, 2024).

The findings analysed throughout this study reveal a structural transformation in the tourism mobility system in Spain, driven by rail liberalisation and the progressive consolidation of high-speed rail (HSR) as the preferred mode for medium-distance travel. This transformation cannot be understood solely through the lenses of modal efficiency or fare reductions. Its impact is broader: it affects territorial accessibility, reconfigures tourism flows, alters the functionality of the airport system, and transforms the sustainability of the travel experience in a transversal manner.

Firstly, the observed effects confirm the initial hypothesis: rail liberalisation has not only altered the modal share between train and air travel but also undermined the operational equilibrium of Madrid-Barajas Airport, particularly through the elimination of domestic feeder flights. Unlike the integrated models observed in countries such as France, Germany, or the Netherlands (Beria and Grimaldi, 2017; Solina and Abramović, 2022), Spain's lack of physical and operational intermodality has exacerbated a functional fragmentation that jeopardises the effectiveness of long-haul air connectivity.

Specialised literature has long emphasised the role of transport as an infrastructure that enables differential access to tourism (Papatheodorou, 2021; Pellegrino, 2021). In this respect, the implementation of HSR has benefited destinations along the most dynamic corridors—particularly those connecting Madrid with Barcelona, Valencia, Málaga, or Seville—while leaving peripheral regions in the north, west, and inland Spain, which lack competitive HSR services, at a relative disadvantage. Nevertheless, it is important to acknowledge that many of these cities were already established tourist destinations prior to HSR implementation, and their growth cannot be attributed solely to rail improvements. As noted by Albalate *et al*., (2017) and Martín *et al*., (2021) the radial model reinforces Madrid's centrality but does not guarantee effective territorial cohesion.

Engaging with previous studies reveals that this concentration of service is not exclusive to Spain. Vickerman (2018) highlights that rail liberalisation in Europe has primarily benefited profitable corridors, often to the detriment of secondary routes. Campos (2015) also warned that one of the risks associated with market liberalisation was the creation

of a dual-speed system, combining highly competitive services with territories excluded from the benefits of the new paradigm. In this context, tourism emerges as a particularly sensitive variable: destinations excluded from HSR networks see their competitiveness limited, while connected destinations gain a comparative advantage through mere network positioning.

From a functional perspective, the relationship between rail and air transport in Spain remains more conflictual than complementary. Although various authors, such as Gundelfinger and Coto (2017) and Aparicio (2021) have argued that intermodality can generate significant synergies, the Spanish case presents multiple barriers: the absence of combined tickets, lack of timetable coordination, physical disconnection between HSR stations and Madrid-Barajas Airport, and weak cooperation between railway operators and airlines. These limitations undermine the traveller's experience and restrict the system's ability to provide seamless and competitive mobility, particularly for international tourists using Madrid as a redistribution hub.

In addition, air transport itself has undergone major structural changes. The rise of low-cost airlines has not only improved accessibility to peripheral destinations (e.g. Bilbao, Santiago, Almería) but also redefined the hierarchy of airport roles. Even airports that are highly specialised in leisure tourism, such as Málaga, now receive more British visitors than Madrid–Barajas (AENA, 2024a). These dynamics challenge a purely centralised reading of Spain's tourism connectivity and underscore the need to consider decentralised flows and airport specialisation in modal planning.

Although the reduction in emissions resulting from modal shift is a clear environmental gain, this potential cannot be fully harnessed without a national strategy for sustainable mobility that places intermodality at its core. As shown by the European Environment Agency (EEA, 2025), HSR emits significantly less CO_2 per passenger-kilometre than aviation, yet its positive impact is diluted if travellers must rely on more polluting means, such as taxis, ride-hailing or private vehicles, for intermediate journeys between stations and terminals.

Nonetheless, the environmental balance of HSR must be approached with greater nuance. While it represents a cleaner option during the operational phase, the construction of Spain's high-speed rail network has generated significant territorial and ecological impacts. These include landscape fragmentation, soil sealing, biodiversity loss, and induced urban sprawl, issues that are often overlooked in public discourse but have been documented by interdisciplinary research in transport geography and spatial planning (Martín *et al*., 2021; Shen *et al*., 2023). Incorporating these critical perspectives is essential to ensure that HSR expansion aligns not only with decarbonisation goals but also with principles of territorial sustainability.

Another significant limitation lies in the model's capacity to deliver inclusive outcomes. While improved accessibility in key corridors increases visibility, it risks concentrating tourism pressure on already saturated destinations (Barcelona, Seville, Málaga) and marginalising regions with potential but low connectivity. As Papatheodorou (2021) and Pellegrino (2021) emphasise, transport not only redistributes flows but also shapes destination hierarchies. Therefore, tourism promotion policies should

integrate multimodal accessibility and strategic connectivity as core criteria for diversifying the national tourism offer.

In terms of governance, institutional fragmentation (across central, regional, public, and private actors) continues to hinder modal integration in Spain. International experience suggests that intermodality is not just a technical challenge, but a political one. Countries such as Italy, Germany, or the Netherlands (Solina and Abramović, 2022) have achieved success through the creation of mixed consortia, unified digital platforms, and regulatory frameworks that promote interoperability and stakeholder coordination.

Finally, this study acknowledges certain methodological limitations that offer avenues for further research. Although the analysis has integrated intermodal simulations and long-haul tourist flows, it is based on a limited number of representative cases. A more systematic approach, incorporating a larger set of origin–destination pairs and disaggregated passenger data, could enhance the generalisability of the findings. Moreover, while this research has focused on travel time and modal configuration, future studies could include variables such as pricing dynamics, digital ticketing integration, passenger preferences, and environmental cost assessments. These dimensions would enrich the understanding of intermodality not only as a spatial or operational phenomenon but as an experiential and behavioural process within the tourism system.

In conclusion, rail liberalisation and the expansion of high-speed rail offer a strategic opportunity to transform tourism mobility in Spain. However, this opportunity will only be fully realised if the logic of modal competition is overcome and replaced by a model of functional integration, collaborative governance, and territorially balanced planning. The challenge is not only to improve infrastructure but to rethink the entire system based on principles of sustainability, accessibility, and multiscalar efficiency.

6. CONCLUSIONS

The liberalisation of rail transport in Spain has led to a decisive transformation of the national mobility system, with significant implications for tourism accessibility. The entry of private operators, combined with fare reductions and service improvements, has encouraged a marked modal shift towards rail for medium-distance journeys, strengthening its competitiveness against air transport.

This process has contributed to a more efficient and sustainable model of mobility, yet it has also generated important side effects: the progressive loss of feeder flights at Madrid-Barajas Airport and a growing territorial inequality between destinations connected to the high-speed rail network and those excluded from it. While the current system shows notable advances, it also presents structural limitations that require urgent and coordinated responses.

One of the keys to overcoming these imbalances lies in achieving real and effective intermodality. The physical, operational, and commercial integration between rail and air transport must become a strategic priority, particularly for long-haul travellers arriving at Madrid-Barajas Airport, which aspires to consolidate itself as a leading hub between Europe, Latin America, and other global markets. This transition requires institutional

cooperation, infrastructure investment, and political commitment to align public and private interests across sectors and territories.

Therefore, we argue that rail and air transport should not be conceived as rivals, but as complementary pillars in the construction of a cohesive, competitive, and low-carbon transport system. This vision requires that intermodality be placed at the centre of infrastructure planning and tourism policy, ensuring both efficiency and inclusiveness. At the same time, it is essential to recognise that the expansion of high-speed rail, despite its environmental advantages in operation, entails territorial and ecological costs that must be mitigated through integrated planning and sustainability safeguards. If investments and regulation are appropriately directed, and if traveller experience and territorial equity are prioritised as central criteria, Spain will be able to consolidate a model of tourism connectivity capable of meeting the challenges of the twenty-first century: a model that is efficient, resilient, sustainable, and designed not merely to move people, but to connect opportunities.

FUNDING

This research was supported by the Iberia–UCM Chair in Air Transport and Global Mobilities. It also forms part of the project CITYEXPERIENCEs (PID2021-123832OB-I00), funded under the "Proyectos de Generación de Conocimiento, 2021" call by the Spanish Ministry of Science and Innovation. The author gratefully acknowledges both institutions for their support.

ACKNOLEDGEMENTS

The author would like to thank the two anonymous reviewers and the editor of the journal for their valuable comments and suggestions, which significantly improved the quality of this article. Special thanks are also extended to A.S.M. for her assistance in refining the colour schemes of the cartographic outputs included in this study.

Authorship statement. The author declares no conflict of interest.

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