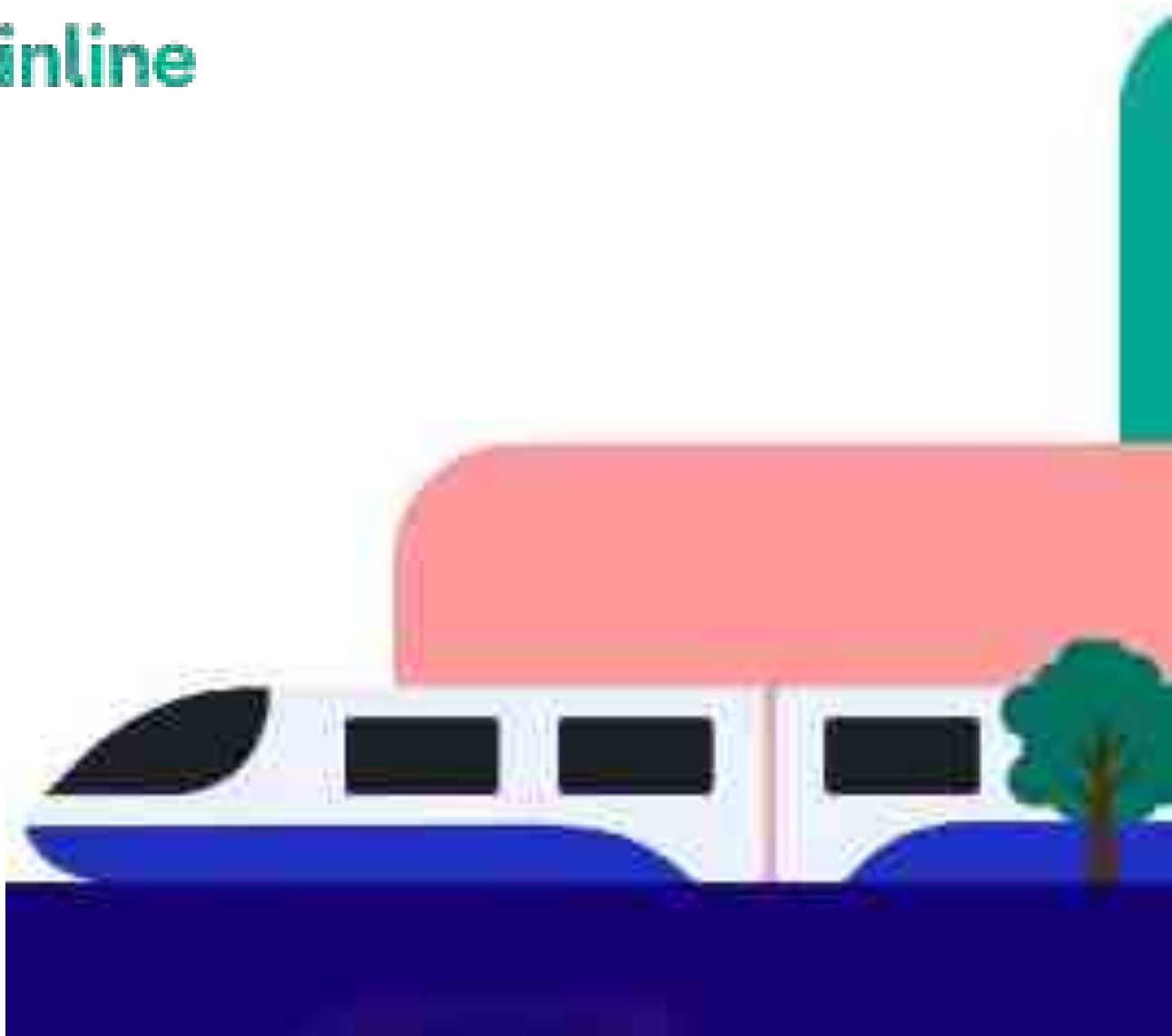


Final Report

BUSINESS MODELS AND VIABILITY OF OPEN ACCESS RAIL COMPETITION IN EUROPE

Prepared for:



BUSINESS MODELS AND VIABILITY OF OPEN ACCESS RAIL COMPETITION IN EUROPE

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1 INTRODUCTION AND EXECUTIVE SUMMARY

Rail liberalisation in the EU has been ongoing for two decades but has gained momentum since 2014, thanks to the 4th railway package, which allows for cabotage and further promotes the opening of domestic markets. The situation has evolved differently between regional Public Service Obligations (PSO) and long-distance open access. Regarding PSOs, the European landscape varies significantly, with some countries and regions already conducting their second or third round of tenders (Alexandersson & Rigas, 2013; Nash et al., 2019), while others still prefer direct awards. In contrast, the open access model is generally adopted for long-distance services, with some exceptions for intercity routes that are – or should be – operated under PSO tenders, similar to regional services.

Regardless of the model, rail liberalisation has brought innovation to the industry and, often, if not always, comes with benefits for travellers. It is not the objective of this study to document the benefits and potential threats of rail liberalisation, as these have been well documented in literature. In particular:

- a. **Higher quality.** Newcomers only rarely adopt a low-cost model. More common is the exploitation of a quality gap relative to the incumbent, which may initiate an upward spiral of quality (Perennes, 2017; Tomeš & Fitzová, 2019; EC, 2024).
- b. **Lower prices.** Incumbent's price decreases caused by the entry of a competitor have been documented in early bird countries: ~35% reduction for early Italian entries of Italo (Cascetta & Coppola, 2015); ~25% reduction for the Milano-Venice in 2018 (before/after) (Beria et al., 2022; Shtele et al., 2024); ~30% reduction (2024 vs 22) on the Madrid-Barcelona due to the triopoly Renfe/Avlo, Iryo, Ouigo (Brenna, 2024); ~21% reduction (2022 vs 19) on the Paris-Lyon (Laroche, 2024).
- c. **More supply.** Competition often evolves into *intensive competition* ("à la Cournot") (Laroche & Lamatkhanova, 2022; Tomeš, 2022; Beria et al., 2023), where the incumbent, in order to maintain a competitive advantage, increases capacity. This, in turn, forces the newcomer to add capacity to be able to maintain prices in line with the competitor's ones (Beria et al, 2025; Bergantino et al., 2015). The outcome is that routes with competition are increasingly used, not seldom reaching a saturation point, but no price-war occurs.
- d. **New connections.** Competitors have sometimes expanded the network by serving previously unserved connections. This did not happen often in the past (in UK, to a limited degree in Italy and Germany, RegioJet for seasonal connections), however it is at the center of the business models of some future players (Arenaways in Italy, LeTrain in France, etc.). The introduction of brand-new services, typically exploiting a cost advantage, could be particularly advantageous for passengers and companies, without the risks of head-on competition.
- e. **More passengers.** The main indirect effect of a well-working competitive landscape is simply the increase of rail passengers. In Italy (a mature market with high speed), the number of market-driven trains increased by 50% between 2010 and 2017, together with load factors (Beria et al., 2019). In Czechia, the decline of incumbent passengers was more than offset by newcomers, resulting in a doubling of the number of passengers on the Prague – Ostrava line. The same source estimates a 20-25% rise of passengers in Austria when Westbahn competition arrived (Tomeš & Jandová, 2018).
- f. **Modal shift.** Part of the additional passengers generated through competition are travelers shifting to rail from other modes (car and plane) (EC, 2024) – this is in particular the case with HS competition.

In addition to these advantages, open-access liberalisation has brought to users a change in the way train travel is experienced:

- g. Users do not have a single or predominant **interface for train searching and ticket purchases** as it was in the era of national companies: different companies operate (and will so more and more in the future) in the same markets with an increasingly intermodal offering.
- h. **Yield management** is widespread in Europe, including monopolistic incumbents' market services and part of the PSOs.
- i. **Unreserved seats** have generally been reduced in long-distance markets. However, some newcomers, such as KevinSpeed, are planning to differentiate from competitors by returning to the unreserved seats model.
- j. Competition, where it exists, has generally brought price decreases, even though **prices are not the only lever of competition**. Balanced duopolistic equilibria typically evolve into frequency and quality wars, rather than price wars (Beria et al., 2023).

For the remainder of this report, we presuppose that liberalization in the rail sector in countries where it has occurred, has brought significant benefits.

In this report, we aim to take a step forward, by identifying:

- a. **business models that are sustainable beyond an initial phase;**
- b. **the routes/markets where such business models are most suitable and sustainable in the long run, but also capable of bringing additional benefits.**

This study has been made possible thanks to the collaboration between **TRASPOL** laboratory (Department of Architecture and Urban Studies, Politecnico di Milano) and **Trainline**, which made available a large dataset of prices and travel time observations.

EXECUTIVE SUMMARY

1. Newcomers entering the European long-distance open-access market cannot be categorised under a single business model, and there is no uniform response from incumbents. Although many years have passed since the first entries under the open-access model (OA, hereafter), the market is far from mature, and many changes and adaptations can be expected in the future during this interesting phase of expansion.
2. In this study, we aim to explore the potential for OA competition in a selection of Western European countries: Italy, France, Spain, Germany, the UK, the Netherlands, Switzerland, Belgium, and Austria. The selection is based primarily on the representativeness of available datasets, rather than solely on market relevance.
3. In short, the study overlays data describing the European economic geography with different OA business models to identify which ones are more likely to develop, and where. All potential origin-destination markets within and between the selected countries have been considered.
4. From a methodological point of view, the study is based on socio-economic spatial data related to the rail network, as well as train, air, and coach prices and travel times. These datasets are used to populate two score indicators: one proxying the **potential demand in a market**, and the other representing its **favorability, given the current intramodal and intermodal competition conditions**. The most promising OD pairs are then assigned to the European rail network, visualising the most promising rail corridors for competition by business model.
5. The business models studied are six, with some variations:
 - a. Conventional Intercity competition
 - b. HS intensive Cournot competition
 - c. Unserved markets
 - d. Night-train competition
 - e. Low-cost competition
 - f. Cross-border

With the same tool, we studied also two more policy scenarios:

- g. Short-haul air transport substitution
 - h. Where to invest to improve rail performances.
6. Our results point to the viability of a variety of different business models for open access across different geographies. The picture is not homogeneous, as socio-demographic, network, and spatial factors make each business model locally more or less adaptable.
 7. Intercity competition on conventional tracks looks more promising in the UK, along an arc from Paris to Hamburg, and within a broad area around the Alps (Northern Italy – Geneva – Stuttgart – Vienna).
 8. Intensive competition on high-speed (HS) tracks (including mixed services), outside of Italy and Spain where it is already in place, is very promising in a broad area between Germany and Eastern France. If we consider the possibility of a third competitor—which is not unlikely—other routes in Italy and southern Spain may see additional entries.
 9. Competition may stimulate the opening of brand-new services between previously unserved city pairs. These connections will likely remain niche, as only smaller markets remain unexploited. Nevertheless, there is apparently room for new connections in Benelux from Paris to Berlin, on the northern flank of the Alps (Montpellier – Munich), and on Italian main lines.
 10. The potential area for the introduction of competing night trains is extensive, covering France, Germany, and Austria, as well as certain routes in Spain and Italy. However, the conditions determined by intermodal competition rarely make them favourable.
 11. Low-cost competition may emerge in various niches across Europe, but its core is represented by Eastern France, Germany, and Southern England, where prices are sufficiently high to encourage the rise of cheaper market segments.
 12. Focusing on cross-border competition, regardless of the type of service, the opportunities are mostly found across France, Benelux, and Germany, as well as in London.
 13. Competition may stimulate the shift from short-haul flights to rail. Overlaying short flight routes with sufficiently performing rail lines produces a somewhat obvious result: on all fast lines in Europe, healthy competition could contribute to environmental goals by reducing flights.
 14. Finally, looking at low-performing lines where potential demand is high yields a nearly empty map: missing links in Europe are located across the Alps, where most of them are already undergoing upgrades.
 15. The above results are based on socio-demographic structure, existing demand, current network performance, and concurrent air and coach markets. To fully assess the feasibility of competition, at least three additional aspects should be considered: Train Access Charges (TACs), saturation levels (actual or induced by timetable organisation), and market power barriers.
 16. In conclusion, despite operating at a very high level of analysis, the study has shown that there is significant potential for new entries into the European rail market. Different business models are favourable in different geographies, demonstrating that the single rail market is anything but homogeneous, reflecting the great variety of urban and economic situations in Europe. In other words, the geographical conditions for a step-up in competition are present, and it is the task of policymakers to make them possible in the short term, both from regulatory and technical perspectives.

2 METHODOLOGY

2.1 DATA SOURCES

The sources were heterogeneous by data point (e.g. passengers vs. market share, average price vs. observed price), representativeness, aggregation and geographical scope (stop to stop, city to city, airport to airport, station to station).

Table 1. Summary of data sources

<i>Dataset</i>	<i>Source</i>	<i>Spatial Detail</i>	<i>Observations</i>
Train Purchase	TRAINLINE	Station-to-station, by company	~157000
Train Research	TRAINLINE	Station-to-station, by company	~2700000
Air Purchase	SKYSCANNER	Airport-to-airport, by company	~5300
Coach Purchase	TRASPOL/CHECKMYBUS	City-to-city, by company	~33000
Sociodemographic data	TRASPOL/EUROSTAT	NUTS3	~1300

The first dataset refers to the Trainline rail purchases and prices, including about 157000 station-to-station OD pairs from the year 2023. For each record we have the origin and destination stations, their coordinates, the carrier's name, the train code and type, the total number of purchased trains¹ as well as various indicators about route prices and duration (average monthly value and percentiles). In addition, every observation is associated to a value representing the weight of that route in each country. This value has been used to aggregate station-to-station observations into city-to-city observations (see section 2.2), but does not give us an absolute indication of the passengers on that particular OD pair. Figure 1 maps the actual stations of purchase of tickets. Noticeable is the different density of observed stations in Italy, France, Switzerland, Belgium, the Netherlands and UK, versus Spain, Austria and Germany. In Spain this is due to the extreme concentration of traffic (irrelevant out of main cities), while in Germany and to a lesser extent in Austria, this results from Trainline's limited penetration, particularly for regional trains.

¹ Not all existing trains are covered, but just those that were purchased during the period. Clearly, ticker OD pairs have a better coverage because more trains were purchased.

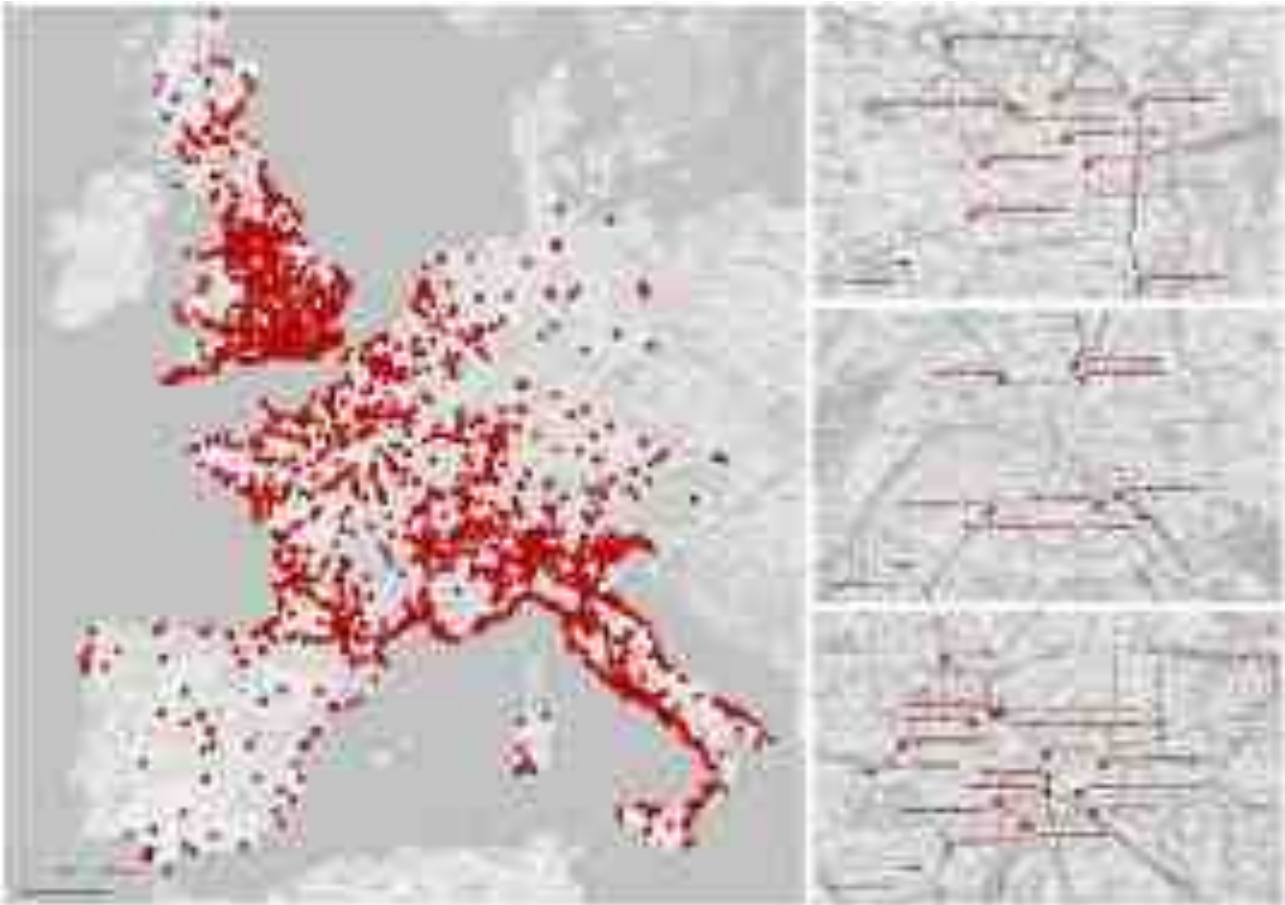


Figure 1. Unique points of Trainline rail purchases and prices dataset.

A second dataset refers to Trainline searches, nearly 3 millions of station-to-station OD pairs in May 2024, which can be grouped into 131000 city-to-city ODs (see section 2.2). They represent the searches that were made on trainline.com by users, even without having completed a final purchase. For each record we have the origin and destination stations and their coordinates, the total number of searches and various indicators about route duration. This dataset is poorer than one for purchases (for example, it doesn't include prices) but guarantees a much better geographical coverage and helps to create a *potential demand* image for the European routes, especially for those that are not served by an existing (or a direct) connection.

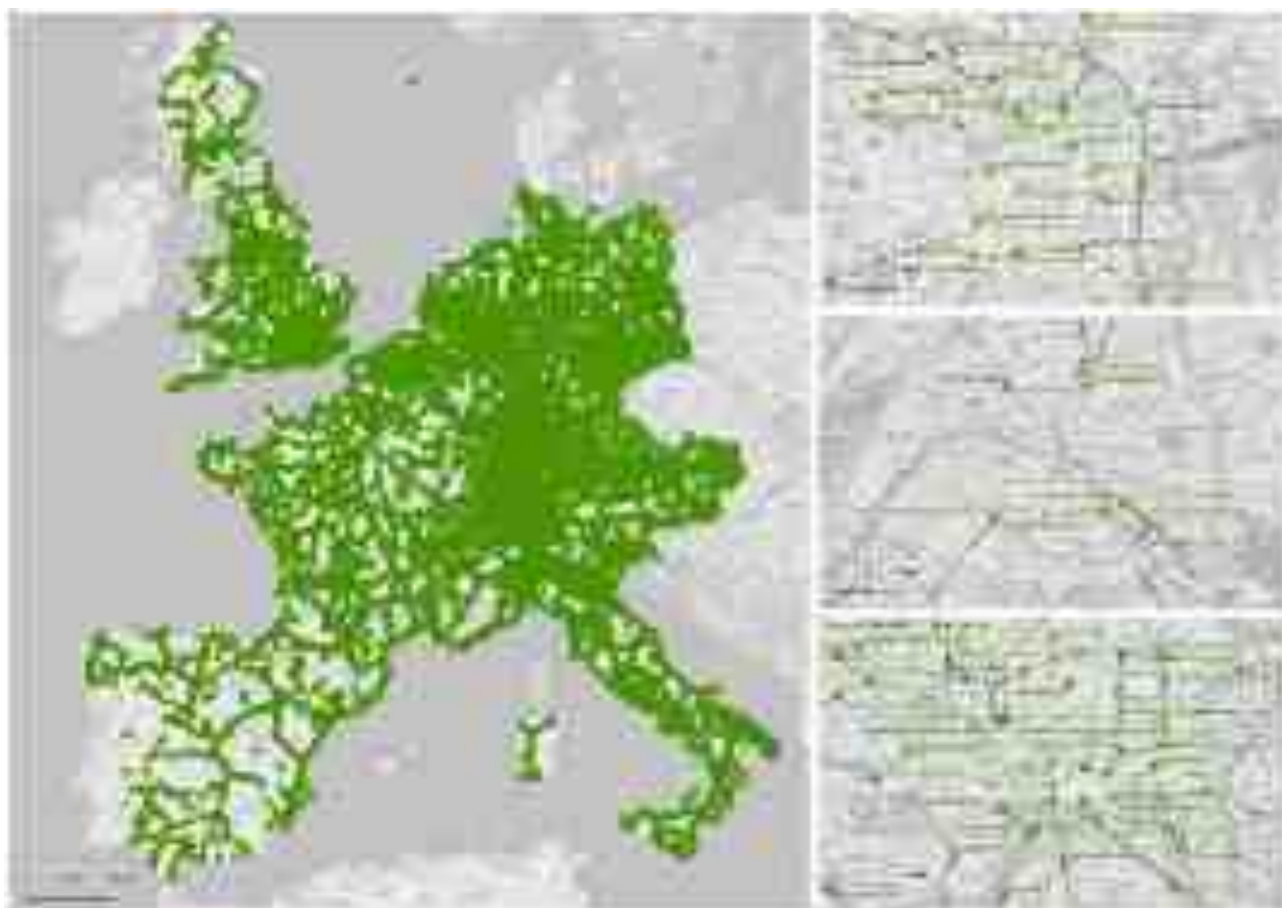


Figure 2. Unique points of Trainline research dataset.

A third dataset includes an extraction of Skyscanner² purchases and prices on airlines, covering about 5300 airport-to-airport OD pairs in the year 2023, reduced to 4500 ODs after geolocalisation. For each record we have the origin and destination airports, the total number of flights and indicators about route prices but also duration similar to train ones.

The fourth dataset, based on TRASPOL elaborations on Checkmybus original data³, refers to city-to-city coach purchases during the year 2023. For each record we have the origin and destination cities, the total number of purchased tickets, the number of operators and the route's HHI⁴, as well as various indicators about route price, road distance, seasonality and tourist share.

Finally, we also processed Eurostat sociodemographic data, to create a geography of Italian cities as described in the following section and attach socio-demographic information to the searches and purchases datasets. The data is detailed at the NUTS3 geographical level and represents population count, young population share, tourists count and GDP.

² The dataset has been provided by Trainline.

³ The data is still unpublished at the European scale. A previous database, referred to Italy only, is documented on: Beria P., Lunkar V., Tolentino S. (2022). *Rapporto sul Mercato delle Autolinee a Lunga Percorrenza in Italia/ Italian long-distance coach transport market report / Year 2021*. TRASPOL Report 1/22 & CheckMyBus. Milano, Italy.

⁴ HHI is the Herfindahl-Hirschman index, representing the level of concentration of a market, from 0 (perfect competition) to 1 (monopoly). It is computed as the sum of the squares of individual market shares, in this case on each route.

2.2 GEOGRAPHICAL SCOPE AND DATA SPATIALISATION

The study was conducted for 5 main countries

- Italy
- France
- Spain
- Germany
- UK

and 4 secondary countries, that were added to maintain a territorial continuity:

- The Netherlands
- Switzerland
- Belgium
- Austria



Figure 3. Analysed countries (in yellow, border countries included to guarantee continuity of international corridors)

One of the first challenges of the study was to create a consistent and homogeneous geographical dataset, to which all our geographically diverse data had to be attributed. Qualitatively, we want to attribute all trains, coaches and flights going to – say – Brussels or London, to the geographical entities named “Brussels” and “London”. This should include everything that administratively belongs to the city, but

also what is part of the urban area without being administratively part of it, such as airports (that are seldom near to the main city) or even gate-stations or peripheral coach stations.

Each of the studied countries had a different kind of internal territorial classification, so we started from EUROSTAT's administrative division ruled by the concept of Local Administrative Unit (LAU). This division is very useful because it covers all the studied countries, but at the same time it has some issues with homogeneity, arising from the different sizes in the smallest administrative levels across Europe. If we consider for example Italy, LAUs are exactly coinciding with the Italian municipalities, which have a good correspondence with the main urban areas of the country, for example Milan (Figure 4 on the left).

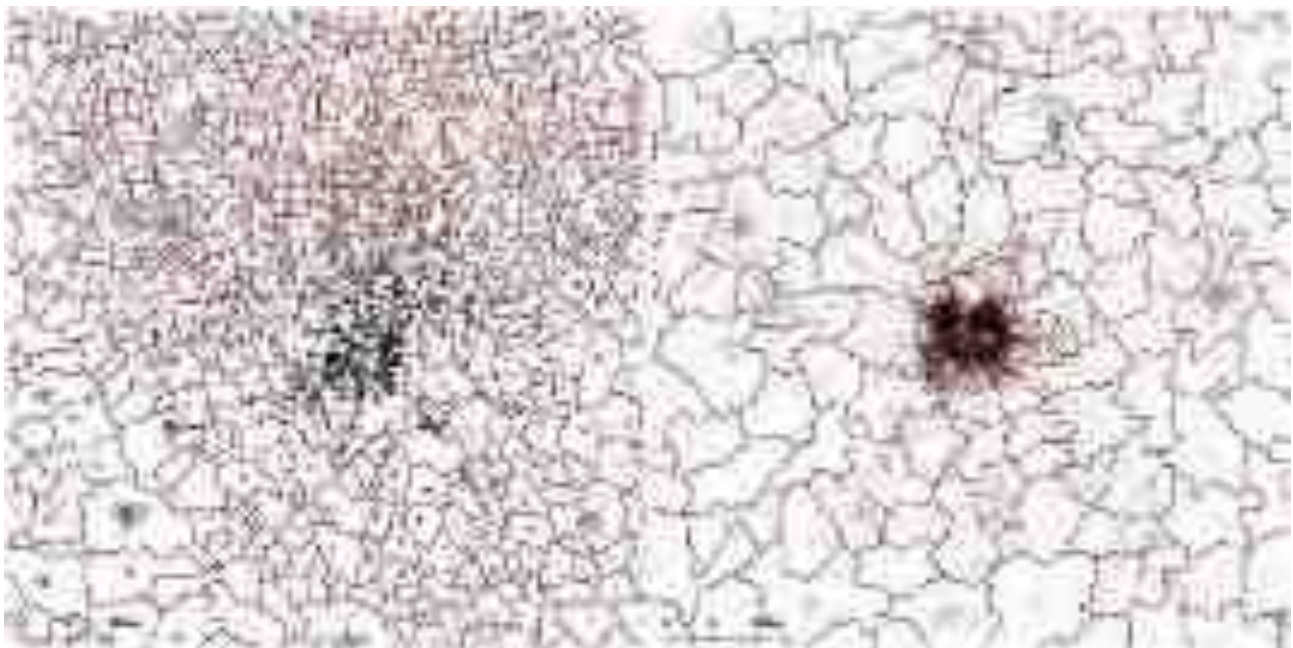


Figure 4. LAU geometries in Milan (left) and Brussels (right) urban areas, at the same scale.

In some other cases, these geometries are less descriptive of the real situation in terms of urbanization. For example, in the case of Belgium, LAUs are larger but have a very limited correspondence with the actual urban structure for example of the capital city, which is administratively split into boroughs. This results in biases, so that the Midi station, which is the main one, is outside the LAU of “Brussels” itself (Figure 4, on the right).

So, the key question has been to define: *what is Brussels?* Or more, in general, how to define the real urban cores inside the selected countries. To fix this problem, we manually checked the data and modified or merged some of the LAUs into bigger and different geometries to catch all the train stations that functionally belong to a city. In particular:

- a. Modifying the borders, if a station that was excluded because of data imperfection (case a. of Figure 5) is actually part of a city;
- b. Aggregating LAUs if they all belong to a clearly recognizable urban area (Brussels, case b. of Figure 5)
- c. Aggregating LAUs to include stations that are located outside the LAU of an urban core but are *the facto* part of it (Rho-Fiera is in the municipality of Rho but “belongs” to Milan, case c. of Figure 5).

Another set of operations throughout the process manually assigned the airports to the correct LAU, based on existing train and bus direct connections to the city center and the general accessibility. These operations define a modified geometry of LAUs, that is used to *reasonably* group stations, stops and airports through a spatial intersection.

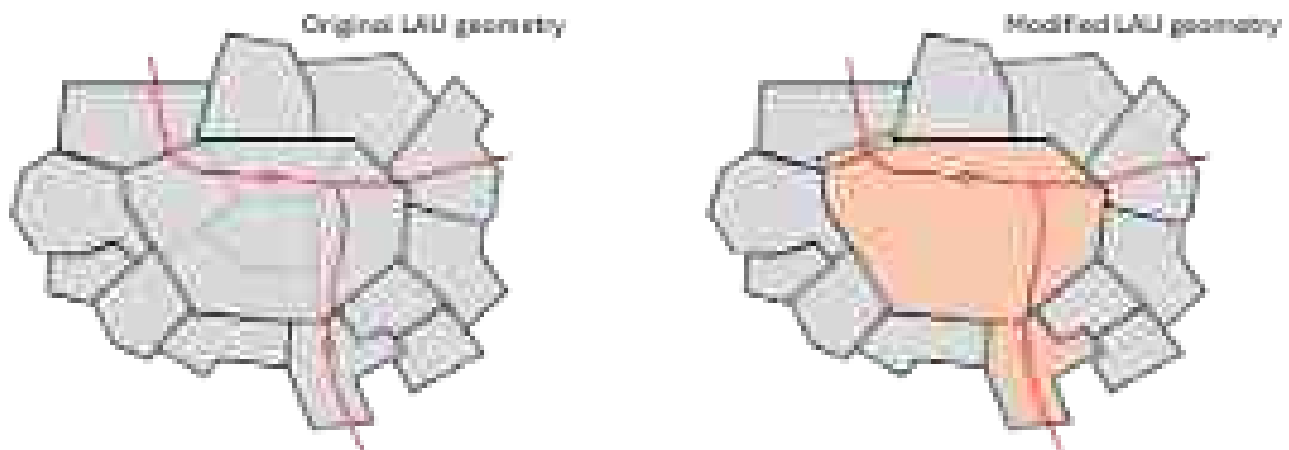


Figure 5. Manual changes and aggregations of LAU geometries to define (in orange) the geometry to which all relevant stations are associated.

A second group of operations aims at attributing realistic socio-demographic data to these geometries. For example, the catchment area of transport services from Paris is larger than the Paris administrative and spatial entity and realistically includes the population located in the municipality of Versailles. In other words, a train operator does not need to stop in Versailles to easily reach its inhabitants. To the contrary, in more isolated or less integrated cities, operators can only rely on locally resident population. To perform this operation, we defined three different classes of urban aggregations:

1. **Cities**, according to EUROSTAT classification and composed by a variable number of LAUs. The population of this class is the one of the entire city, artificially concentrated in the geometry of the main LAU.

To select the other two classes, we had to use a more complex approach. Since we wanted to keep only the dense urban areas and avoid including areas of sparse urbanization, we computed the amount of population living inside dense urban tissue in each LAU using a 1km grid population data and we kept the most populous dense cluster for each LAU. From these clusters, we defined the other two classes:

2. **Medium size urban cores**, any LAU outside *cities* and *Functional urban areas (FUAs)*, including a main cluster of more than 40k inhabitants. The population is the one of the LAU.
3. **Small size urban cores**, any LAU outside *cities* but possibly inside *FUAs* including a main cluster of more than 30k inhabitants and less than 50k. The population is the one of the LAU.

Figure 6 shows an example for the Milan area. All red areas are the main LAU of a EUROSTAT *city* and collect the whole *city* population (larger than the one of the LAU). Orange areas are LAUs with an urban core of at least 40k inhabitants, while yellow ones are LAUs including an urban core that would be excluded by the classification because they are part of a FUA. This is the case of Lodi, belonging to Milan's FUA but functionally separated and normally served by intercity trains.

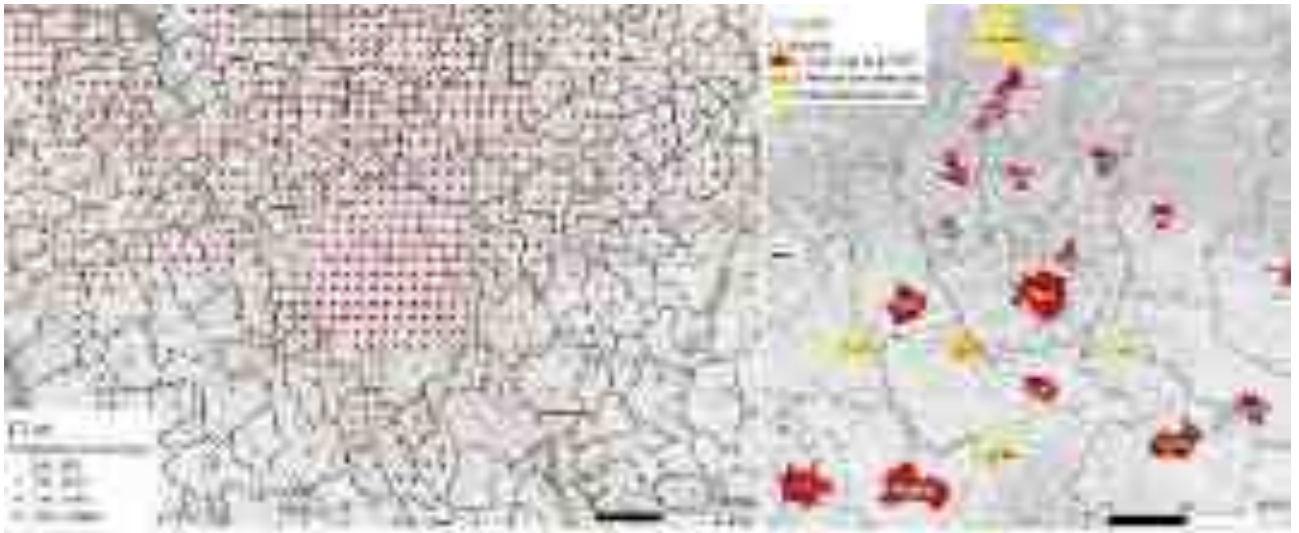


Figure 6 Population density clusters (on the left) and LAU classification in Lombardy, Italy.

A slightly different approach has been used for the UK. The problem with the UK is the shape of the urbanised area and the division into LAUs, which are extremely different compared to the rest of Europe. For this reason, we had to rely on the concept of *Greater City* and *City* provided by EUROSTAT only for UK. These two become our first two classes. The third class is created again with clusters and represents in particular all those LAU outside *Greater City* and *Cities* and with a main cluster of more than 50k inhabitants.

The above-described operations bring us to the “reduction” of the territory of our study area to a limited number of geometries (905) well representing the main urban cores where an intercity train could stop. The geometries include all relevant stations of the node but represent the population of the entire urban area. In addition to these city geometries, we also added the top 200 airports by passengers in 2023, each one associated to one or more LAUs.

Any price or demand observation out of this selection is discarded (to reduce the computational burden), but at the same time these areas largely represent the bulk of European long-distance demand.

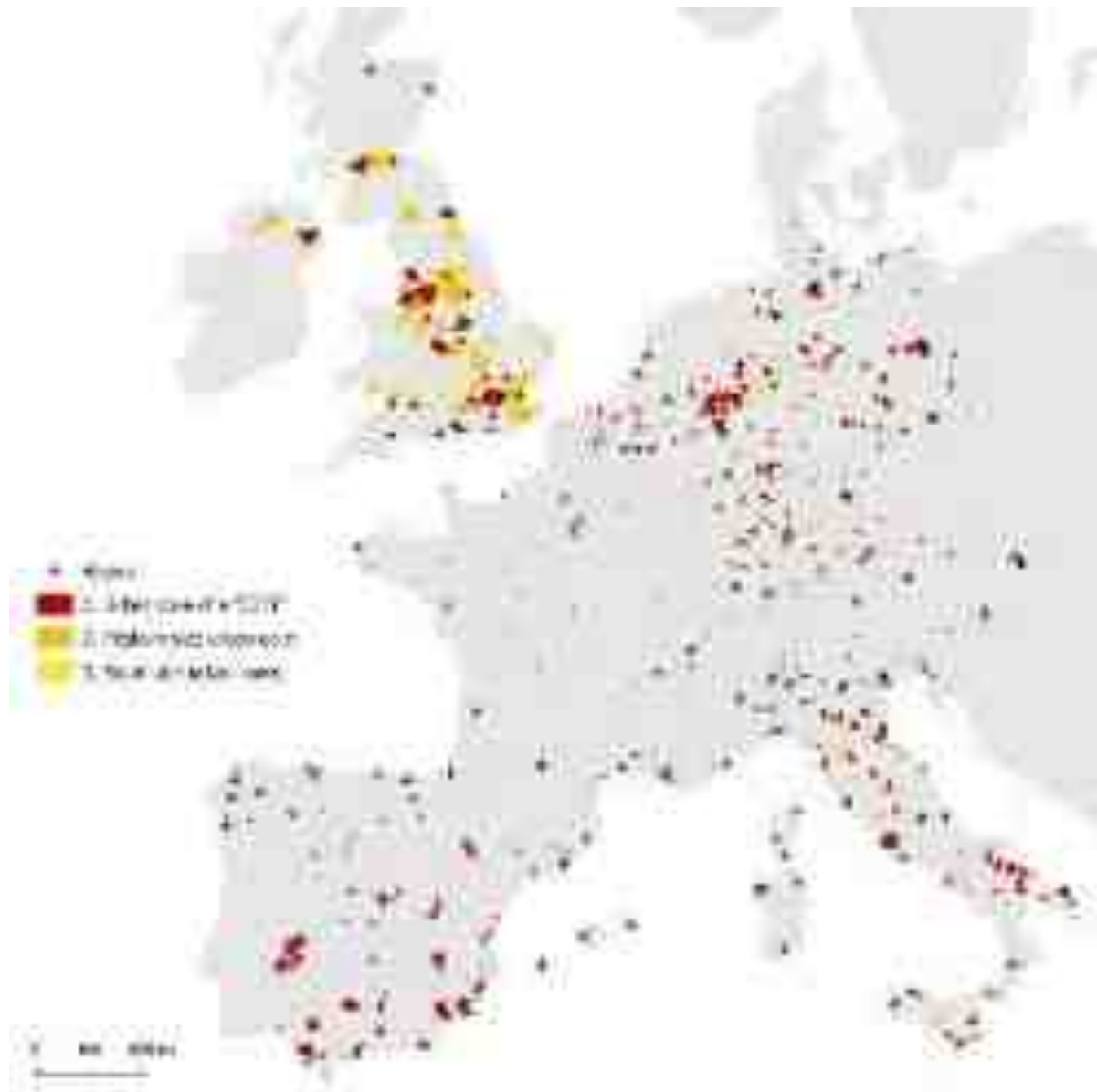


Figure 7. The 905 spatial units (LAUs and airports) considered for the case study

2.3 GENERAL METHODOLOGY

This section describes the workflow followed to aggregate the heterogeneous datasets into one single database, to perform the calculation of indicators and to define the scenarios representing different business models that a newcomer may adopt to enter a market.

The entire approach is summarised in Figure 8. The input datasets come with different native granularities: traffic data is associated to stations/stops/airports, while socio-demographic data is either at the LAU or NUTS3 level. All datasets must be linked reciprocally, and this is done by associating them to the zones described in the previous Section 2.2. Traffic data is linked through a spatial intersection of origin and destination stations with origin and destination zones. Socio-demographic data is associated to both origin and destination zones through the rules previously described.

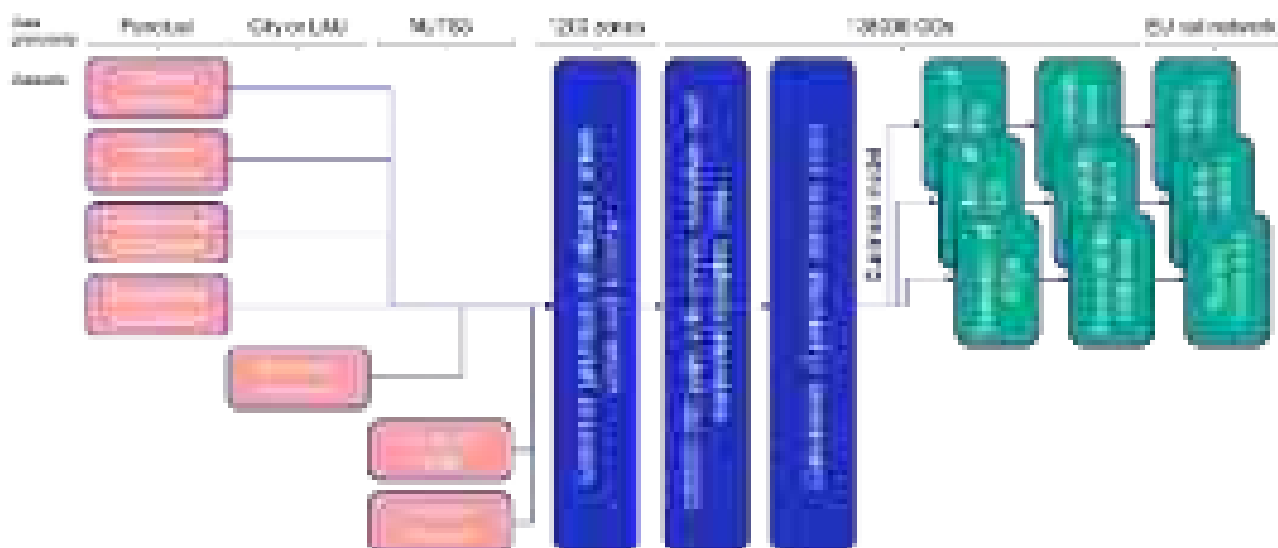


Figure 8. General methodological scheme.

At the end of this process the dataset has the structure exemplified in Table 2, where data related to origins and destinations is associated to OD data such as prices, travel time and number of operators.

Table 2. Example of unified dataset.

Year	Origin	Destination	Sociodemo_O	Sociodemo_D	Searches_data_OD	Purchases_data_OD	Buses_data_OD	Air_data_OD
2023								

The fields of the database are described in the following Table 3.

The calculation of OD-based indicators (score and favourability) is described in the following sections.

Table 3. List and description of the full dataset variables. In bold main indicators used in the analysis

Field	Description	Data origin
Origin	Origin zone / airport	Zoning
Destination	Origin zone / airport	Zoning
Distance	Distance between zone centroids computed by routing on the rail network graph	Routing procedure
name_O	Full name of the origin zone / airport	Zoning
country_O	Country of origin	Zoning
name_D	Full name of the destination zone / airport	Zoning
country_D	Country of destination	Zoning
Intl	International OD pair (1/0)	Zoning
OD_Routing_ID	ID of the directional OD pair (used for routing join)	Routing procedure
OD_ID	ID of the OD pair (both directions)	Routing procedure
SRC_count	Number of Trainline searches of the OD pair (May 2023)	DB_Trainline_searches
SRC_time(h)	Average travel time (in hours) obtained from Trainline searches of the OD pair (May 2023)	DB_Trainline_searches
Speed_RAIL	= Distance / SRC_time(h)	
minPOPij	Minimum zone population between origin and destination zone	Zoning
minGDPij [M€]	Minimum NUTS-3 GDP (in M€) between origin and destination zone	Zoning
PAXtot	Yearly passengers per airport (0 if the zone is a city)	Zoning
PRC_carriers	Number of different companies by OD pair (0 if the pair is not purchased)	DB_Trainline_purchases
scoreSEARCH	Potential demand score, part based on Trainline searches	
scorePOP_city2citytime	Potential demand score, part based on city-to-city population	

scorePOP_city2airp	Potential demand score, part based on city-to-airport population	
scoreGDP	Potential demand score, part based on GDP	
scoreSOCDEM	Potential demand score, part based on socio-demo indicators	
scoreTOT	Potential demand score	
searched/potential ratio	= scoreSEARCH/scoreSOCDEM	
PRC_HHI_supply	HHI index (rail competitors) of the OD pair, based on supply	DB_Trainline_purchases
PRC_LC/tot	Share of low-cost rail products on total supply	DB_Trainline_purchases
PRC_HHI_pax	HHI index (rail competitors) of the OD pair, based on demand	DB_Trainline_purchases
PRC_Pax_dir_tot	Normalised purchases, only direct connections	DB_Trainline_purchases
PRC_paxHS	Normalised purchases, only HS connections	DB_Trainline_purchases
PRC_paxC	Normalised purchases, only conventional IC connections	DB_Trainline_purchases
PRC_paxR	Normalised purchases, only regional connections	DB_Trainline_purchases
paxR/tot	= PRC_paxR/ PRC_Pax_dir_tot: share of regional tickets over total direct tickets	
PRC_Pax_ind_tot	Normalised purchases, only indirect connections	DB_Trainline_purchases
PRC_Pax_tot	Normalised purchases, total	DB_Trainline_purchases
PRC_Pax_INdir/tot	= PRC_Pax_ind_tot/PRC_Pax_tot: share of indirect tickets over total tickets	
PRC_PkmAVG_dir_HS	Average price per km (all carriers) for direct HS connections	DB_Trainline_purchases
PRC_PkmAVG_dir_C	Average price per km (all carriers) for direct conventional IC connections	DB_Trainline_purchases
PRC_PkmAVG_dir_R	Average price per km (all carriers) for direct regional connections	DB_Trainline_purchases
PRC_PkmAVG	Average price per km (all carriers), all train types	DB_Trainline_purchases
zsRAIL_avg_pricekm	= zscore of PRC_PkmAVG	
Price25_dir	25 th percentile price of direct connections (as a percentage of average price)	DB_Trainline_purchases
Price75_dir	75 th percentile price of direct connections (as a percentage of average price)	DB_Trainline_purchases
PRC_priceexc	= Price75_dir – Price25_dir: price variability	
zsRAIL_priceexc	= zscore of PRC_priceexc	
PkmSKY	Average price per km (all carriers), airlines	DB_Skyscanner
PkmCMB	Average price per km (all carriers), coaches	DB_Checkmybus
zsSKY_avg_pricekm	= zscore of PkmSKY	
zsCMB_pricekm	= zscore of PkmCMB	
CMB_Qpax	Purchases per year, coach	DB_Checkmybus
zsCMB_Qpax	= zscore of CMB_Qpax	
SKY_Qsupply	Flights*purchases per year	DB_Skyscanner
zsSKY_Qsupply	= zscore of SKY_Qsupply	
maxspeed_HS	Speed of the 75 th fastest HS connections (only purchased pairs)	DB_Trainline_purchases
maxspeed_C	Speed of the 75 th fastest conventional connections (only purchased pairs)	DB_Trainline_purchases
maxspeed_R	Speed of the 75 th fastest regional connections (only purchased pairs)	DB_Trainline_purchases
maxspeed_SKY	Speed of the 75 th fastest air connections (only purchased pairs)	DB_Skyscanner
speed_adv_SKY	= maxspeed_SKY – Speed_RAIL: speed advantage of air transport, incl. 3h access time	

2.4 O-D POTENTIAL DEMAND (SCORE)

An ideal indicator to represent potential demand cannot be – by definition – derived from direct demand observations. Moreover, comprehensive and spatially detailed demand data does not exist (e.g., passengers travelling from Brussels to Amsterdam) as it is fragmented among many operators, who keep this commercially sensitive information safe, as well as ticketing platforms. Commonly, potential demand

is determined through demand modelling tools, such as transport models, starting from spatial (e.g. distance, distribution of origins and destinations, etc.) and sociodemographic data (income, GDP, etc.). In this study, however, we have important added value data points: the searches performed by users on the Trainline ticketing platforms. Not all searches, in fact, turn into a purchase of a ticket and travelling. As they outnumber actual travels, searches are providing us with an extremely detailed and comprehensive overview of European trips, including potential ones.

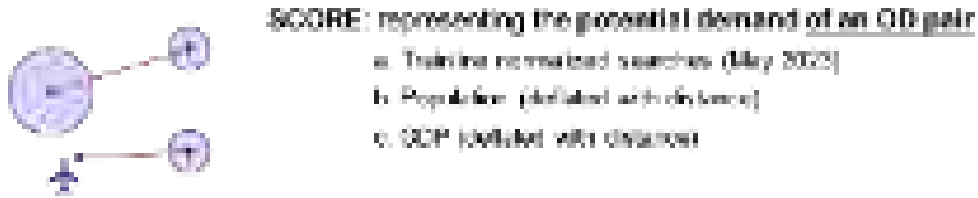


Figure 9. Schematisation of the Score, that is the potentiality of an OD pair.

To quantify the **potential of an OD pair** for competition, we combined different methods. This approach blends the uncertainties of both basic approaches: the impossibility of models to reproduce spatial deformations (e.g. the corridors of national and European immigration of decades ago), and the partiality of Trainline's observed searches (that are biased by the different penetration of the platform). To do so, we define a "score", that is the sum of two components of searches and sociodemographic modelling:

$$\text{scoreTOT} = \text{scoreSEARCH} + \text{scoreSOCDEM}$$

where:

$$\text{scoreSEARCH} = \text{SRC_count} / \gamma / \text{carriers}$$

with γ representing a coefficient normalising the searches with country population of origin. γ is larger if Trainline represents many searches per capita and smaller if Trainline is less used in the country with respect to its population. This "inflates" the numbers of countries underrepresented, making search figures more comparable and independent of Trainline's presence.

The use of a comparative platform like Trainline is more likely and frequent when we have more competitors in a market and less if there is just an incumbent company. This is particularly visible in Spain, where the sudden appearance of two new companies on some HS routes in addition to the well-known RENFE has made comparison apps useful and widely used. For this reason, we adjust the searches with the number of carriers competing, as the potential demand for such OD pairs should not be overrepresented just because Trainline is more commonly used.

The second component of scoreTOT is scoreSOCDEM, representing the fact that potential demand is more if the places connected are "large" and "near", and less for "small and far" pairs.

The score is different for pairs involving two cities (first case) or a city and an airport (second case).

$$\text{scoreSOCDEM} = \begin{cases} \min POP_{ij} \frac{w}{1 + e^{-k(\text{time} - \text{time}_0)}} + \min GDP_{ij} \frac{\alpha_1}{\text{Distance}^{\beta_1}}, & \text{if } i \wedge j = \text{cities} \\ \min POP_{ij} \frac{\alpha_2}{\text{Distance}^{\beta_2}}, & \text{if } i \vee j = \text{airport} \end{cases}$$

If the pair involves two cities, the score is the sum of a population-based component and a GDP-based component, both directly related (the higher the value, the higher the score). In all cases, we consider the smallest population or GDP of the pair, to avoid overestimating flows to main cities.⁵

Population is deflated with distance according to a logistic function, with three parameters k , w and SRC_time_0 . The logistic function gives a high weight w to “near” pairs, a nearly zero weight to “far” pairs and an intermediate value around the midpoint SRC_time_0 . The “steepness” of the passage between “far” and “near” pairs is ruled by the parameter k . In the simulations, we use the following parameters, giving the function in Figure 10.

$$k = -1$$

$$w = 0.15$$

$$SRC_time_0 = 7 \text{ hours.}$$

These parameters determine that the score is the highest (about equal to $0.15 \cdot \text{population}$) for trips up to 4 hours by train. For trips longer than 10 hours the (rail) interaction between the two goes to zero. In between, the function is almost linear around 7h. Notice that the travel time is the actual average time, obtained from the Trainline searches dataset.

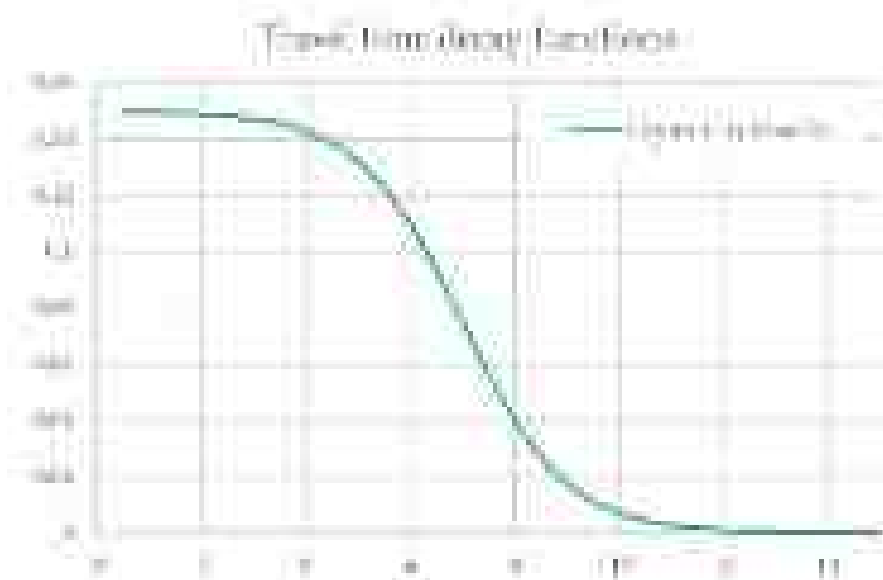


Figure 10. Travel time decay function for population of city pairs.

The influence of both GDP (for city pairs) and the population of the city connected to an airport is deflated with a distance-decay function, ruled by two parameters.

$$\alpha_1 = 15000, \beta_1 = 2.5 \text{ (city-to-airport)}$$

$$\alpha_2 = 10, \beta_2 = 0.6 \text{ (GDP)}$$

Figure 11 shows the effect of the parameters. The population in airport pairs goes to zero at about 300km, to take into account that probably another nearer airport is available in between. The influence of GDP falls slower, with a weight of 0.25 of GDP at 500km.

⁵ For example, the demand between Mons and Paris does not depend on the population of Paris or on the total of the two (that means $\sim$ Paris), but primarily of the smallest, Mons. Clearly, this underestimates the flows from small to large cities, but this is counterbalanced by the other indicator, the *scoreSEARCHES*.

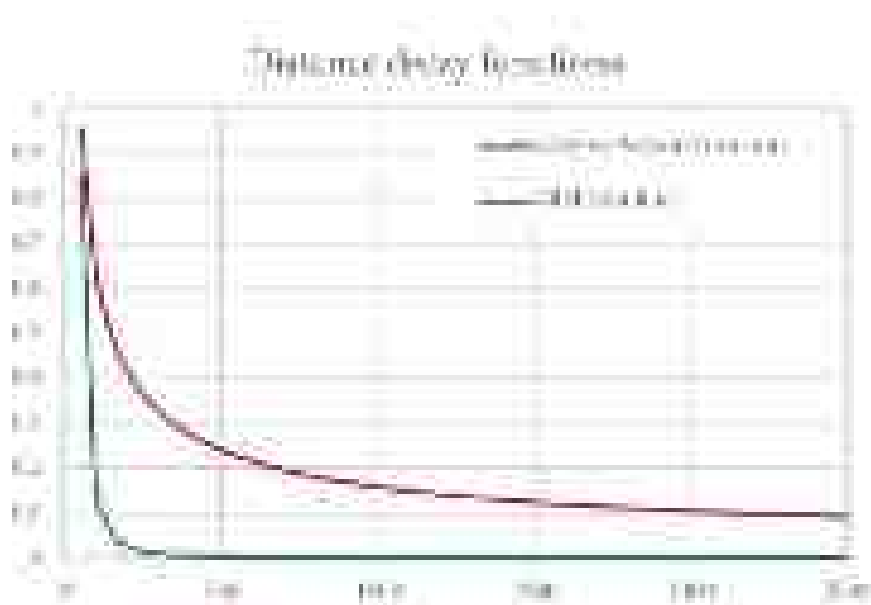


Figure 11. Distance decay function for GDP and population of city-airport pairs.

These functions have been estimated empirically, based on a realistic influence of distance or travel time on the independent variable (pop or GDP).

Potential demand score is represented as the thickness of lines or corridors in maps of Section 3 and 4.

2.5 BUSINESS MODEL SCENARIOS AND ROUTES FAVOURABILITY

The **score** described above, proxies the intrinsic potential demand of an OD pair. However, a high potential on a pair is not, per se, guarantee of the feasibility/likeliness of the entry of a competitor. In fact, other factors matter, such as the competitiveness of rail and the presence of intermodal competition. For example, a potentially dense corridor is not likely to develop competition if air transport is particularly strong, but also if the line is particularly slow (rising production costs and lowering competitiveness) or if prices of the incumbent are already low.

In this section, we develop another measure in addition to the OD Score, that characterise the OD itself in terms of how **favourable** the framework conditions are to competition. Figure 12 summarises the eight indicators considered to build the Favourability indicator, as explained below.

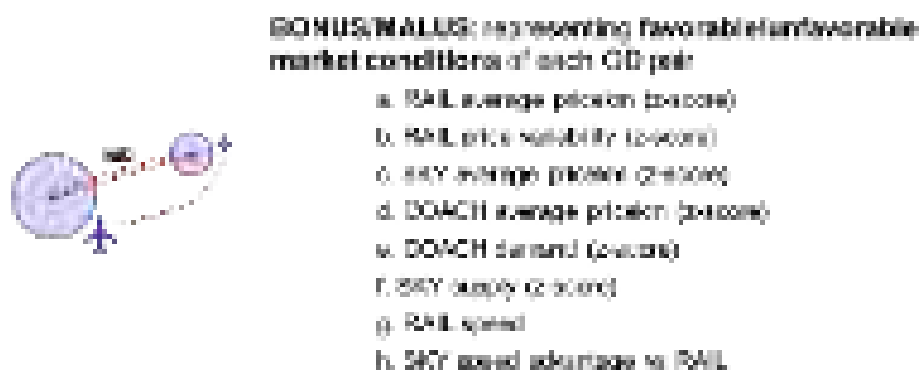


Figure 12. Schematisation of the Favourability, that is a bonus/malus summarising the favourability for a competitor to enter that pair.

- a. **Z-score of average rail price/km:** high scores represent OD pairs whose price per km of incumbents is higher than the average price. A high price for the incumbent's services is favourable to competition.

- b. **Z-score of rail price variability:** high scores represent OD pairs where the difference between discounted and highest prices is large. Low scores mean that there is no price escalation. The effect for competitors is not univocal. The lack of variability in prices may be due to either the absence of yield management and traditional km-based pricing, or a mismatch between demand and supply pushing up prices. In terms of competition favourability, the effect is negative in the first case and very positive in the second; each scenario will define the sign of the effect according to framework conditions.
- c. **Z-score of average air price/km:** high scores represent OD pairs whose price per km of air alternatives is high with respect to the average ones. A high price of competing air services is favourable to competition.
- d. **Z-score of average coach price/km:** high scores represent OD pairs whose price per km of coach alternatives is high with respect to the average ones. A high price of the competing coach services is favourable to competition.
- e. **Z-score of coach demand:** high scores represent OD pairs where coach is serving a high number of passengers with respect to average ones. High demand of the competing coach services is favourable to competition because it represents a larger pool to attract new passengers from.
- f. **Z-score of air supply:** high scores represent OD pairs where many air connections exist with respect to average ones. In absence of reliable information concerning demand and assuming that air transport supply closely adheres to demand (relatively constant load factors), a high supply of competing air services is favourable to competition because represent a larger pool from which to attract new passengers.
- g. **Rail speed:** high scores represent OD pairs where trains are fast, and faster trains are favourable to competition both because they are more attractive and because production costs are lower (higher factors productivity). The scale of scores is described scenario by scenario according to the type of product.
- h. **Air transport speed advantage with respect to rail:** high scores means that planes are much faster than current train options.⁶ Faster air transport reduces rail's relative competitiveness, making it less favourable for competition, as air already serves as an alternative to trains.

Z-scores, where applicable, are computed as follows. The value of an observation (X), such as the price per km of a certain OD pair, is transformed into a relative score (Z) by subtracting the average value $\bar{X}$ of the series (prices per km of all OD pairs of the scenario) and dividing by the standard deviation σ .

$$Z = \frac{X - \bar{X}}{\sigma}$$

Each score is transformed into a bonus/malus ranging from -3 to +3 according to scales defined in each scenario and described in paragraphs 3.1 to 3.8. Bonus/malus are summed up with a weight = 1, so the final **Favourability score** ranges from -24 to +24 and is represented as the colour of lines or corridors in maps of Section 3 and 4.

2.6 ROUTING

The previously described procedure selects, for each scenario, OD pairs that match the criteria. Each OD pair is associated to a Potential Demand Score and to a Favourability Score. This selection of ODs is ultimately mapped to the real rail network to highlight the corridors/lines where such potential demand will be concentrated.

⁶ Including a fixed access time to the airport of 3 hours.

The network assignment is based on a railway graph, purposely built, and including *high speed lines*, *main lines* and *secondary lines* classified in terms of typical speed (Figure 13).

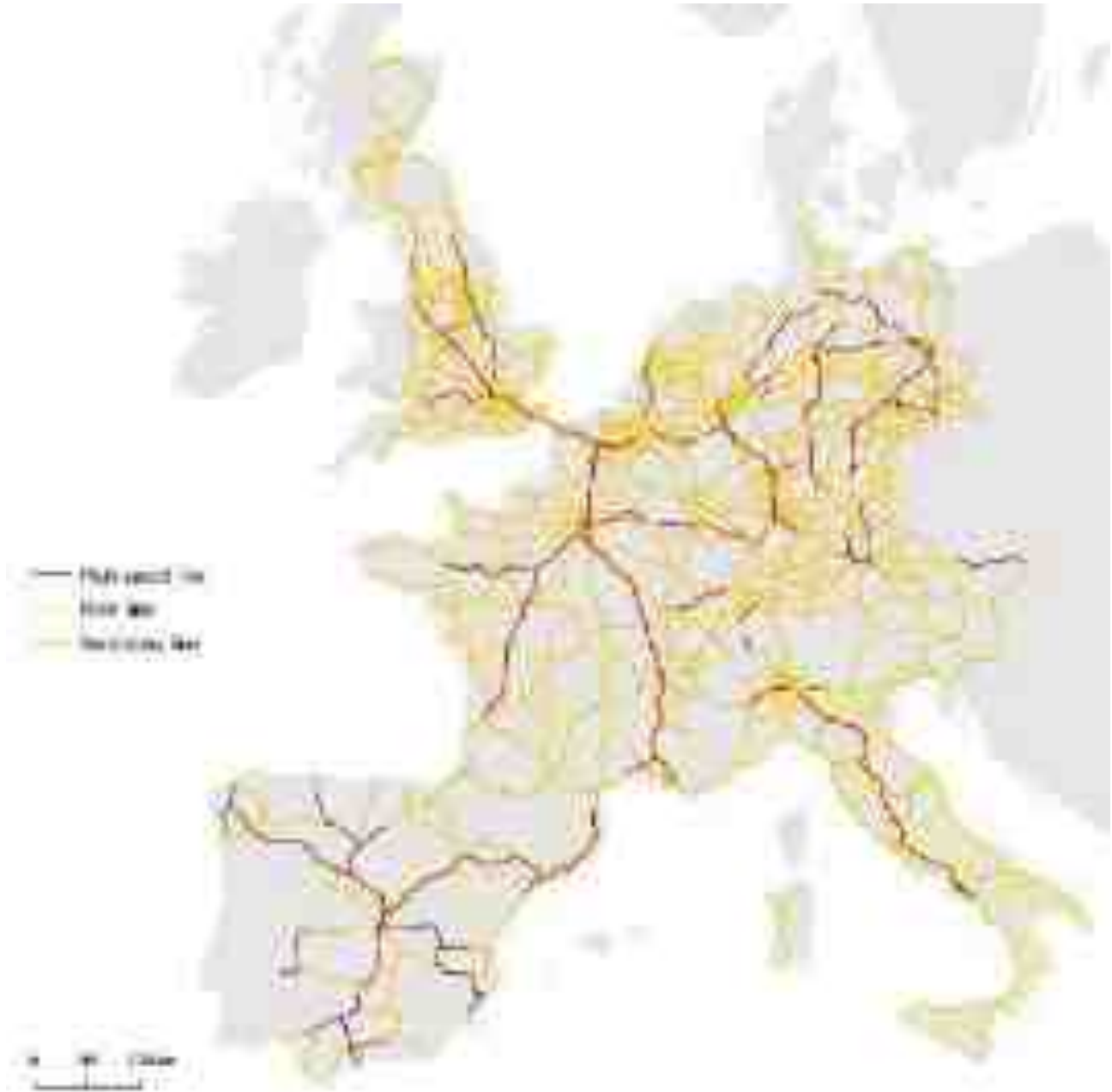


Figure 13. Railway graph used for routing

We performed a routing algorithm on this graph, assigning each OD pair on it and iteratively checking its consistency. The routing is used also to calculate the real rail distance between the different nodes/cities (variable *Distance*).

Clearly, the path is not necessarily the real one, especially where alternative parallel paths exist. However, the consistency checks performed reasonably well. For example (Figure 14), trains from Milan to Rome prefer the HS line even if it is not the shortest (via Genova is shorter). Similarly, Milan-Munich passes through the Brenner and not via Switzerland.



Figure 14. Routing between Milan and Paris, München, Rome

This procedure makes it possible to visualize the analysed scenarios on the real railway network and no longer through line strings. To do so, we combined single routings, computing the indicators consequently. Basically, segments composing all routes have been selected. The *total score* of each segment is the sum of scores of each routing and the *bonus* is the average, weighted with the *total score* (Figure 15).

In the following chapter we will present both the hypotheses and results of all the considered scenarios in terms of single line strings and dissolved routings.

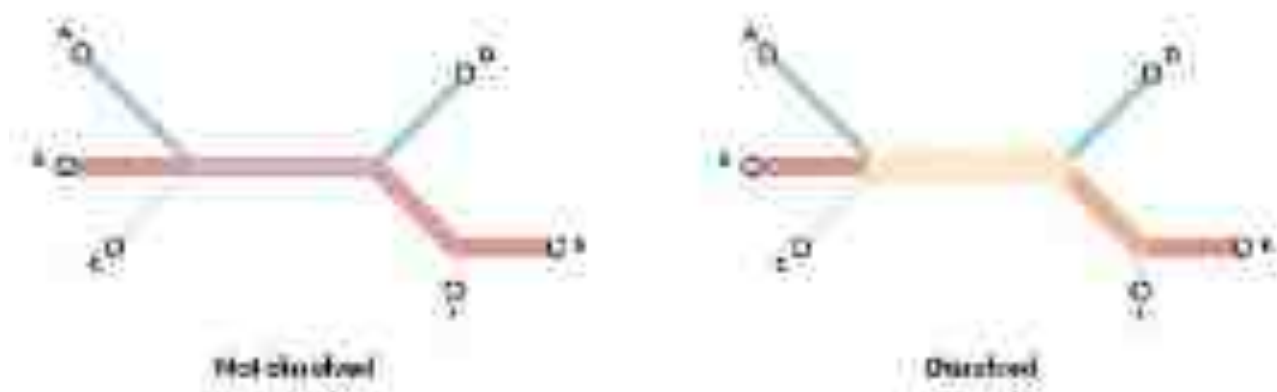


Figure 15. The basic mechanism of the routing dissolve algorithm

3 SCENARIO RESULTS

The operations described in the previous section result in the selection of a variable number of city pairs for each business model scenario, each characterised by a potential score (representing the relative potential rail demand) and a bonus/malus score (indicating the favourability of intermodal market conditions). These OD pairs are also mapped onto the European rail network, grouping them along the most likely corridors.

In this section, we will introduce the criteria defining each scenario and separately discuss the resulting selection of OD pairs and corridors.

Eight scenarios are simulated. Six represent different business models for a competitor entering a market:

1. **IC competition** (long-distance & fast conventional OD pairs)
2. **Intensive à la Cournot competition** on mixed-HS networks
3. **New services** (unserved direct OD pairs with Trainline searches)
4. **Night trains**
5. **Low-cost, no-frills competition** (dense IC and coach routes)
6. **International services**

Two additional scenarios represent policy considerations rather than intramodal competition and are simulated using the same approach:

7. **Air competition** (air routes that could be challenged by rail)
8. **Investment priorities** for improving rail performance.

3.1 SCENARIO 1 – INTERCITY COMPETITION

The scenario aims to select the OD pairs most suitable for the entry of a competitor in the conventional IC segment. We focus on medium-distance routes, excluding long journeys that would typically be made by aeroplane, as well as short journeys where subsidised regional trains could weaken the newcomer. We also exclude OD pairs connected by HS lines (considered in the next section) and OD pairs where there are already two or more operators. However, we do include OD pairs purchased as indirect connections.

In summary, the conditions of the scenario are as follows:

- ✓ Distance 200-500 km
- ✓ No or few regional trains (<20%)
- ✓ No HS on the same OD pair
- ✓ No train competition on direct OD pairs. Indirect OD pairs considered

Regarding the favourability indicators, Table 4 below details the value set. The first four indicators describe the prices of the competing operators (incumbent rail) and modes (air and coach). Positive z-score values indicate that route prices are above the market average, granting an additional 1 to 3 points. Conversely, low fares correspond to “poor” markets – for example, due to subsidies – and result in a malus to the favourability score. The same applies to price variability: in a rail monopoly, a broader range of prices is typically associated with effective yield management and, consequently, higher revenues. This also represents a favourable situation for the newcomer, which can enter the market with high prices during peak demand.

The fifth indicator reflects the demand for coach services (tickets sold via the CheckMyBus platform). Routes where coaches sell a large number of tickets indicate potentially “large” markets, which are again more favourable to a rail newcomer. However, we do not assign a corresponding bonus for the air market, given the short distances in this scenario.

Finally, the last two indicators measure the competitiveness of rail, both in absolute terms and relative to air. The speed scales have been chosen in line with the service types. A commercial speed of 80 km/h is considered the average value.

Table 4. Favourability parameters, scenario 1 (IC competition)

bonus points	-3	-2	-1	1	2	3
RAIL average price/km (2-score)	-infinite	-0.75	-0.5	0	0.5	infinite
RAIL price variability (2-score)	-infinite	-0.75	-0.5	0	0.5	infinite
SKY average price/km (2-score)	-infinite	-0.5	-0.2	0	0.2	infinite
COACCI average price/km (2-score)	-infinite	-0.5	-0.2	0	0.2	infinite
COACCI demand (2-score)	-infinite	1	0.2	0	-0.2	-infinite
SKY supply (2-score)	-infinite	1	0.2	0	-0.2	-infinite
RAIL speed	-infinite	40	60	80	100	infinite
SKY speed advantage vs RAIL	-infinite	20	20	1	-20	-infinite

The results of the scenario are mapped in Figure 16 and Figure 17, representing respectively the ODs and the corridors. The size of the lines represents the score (see Section 2.4) and the colour the favourability score. In both cases, the higher the two indicators, the better is the potential for competition of the route/corridor.

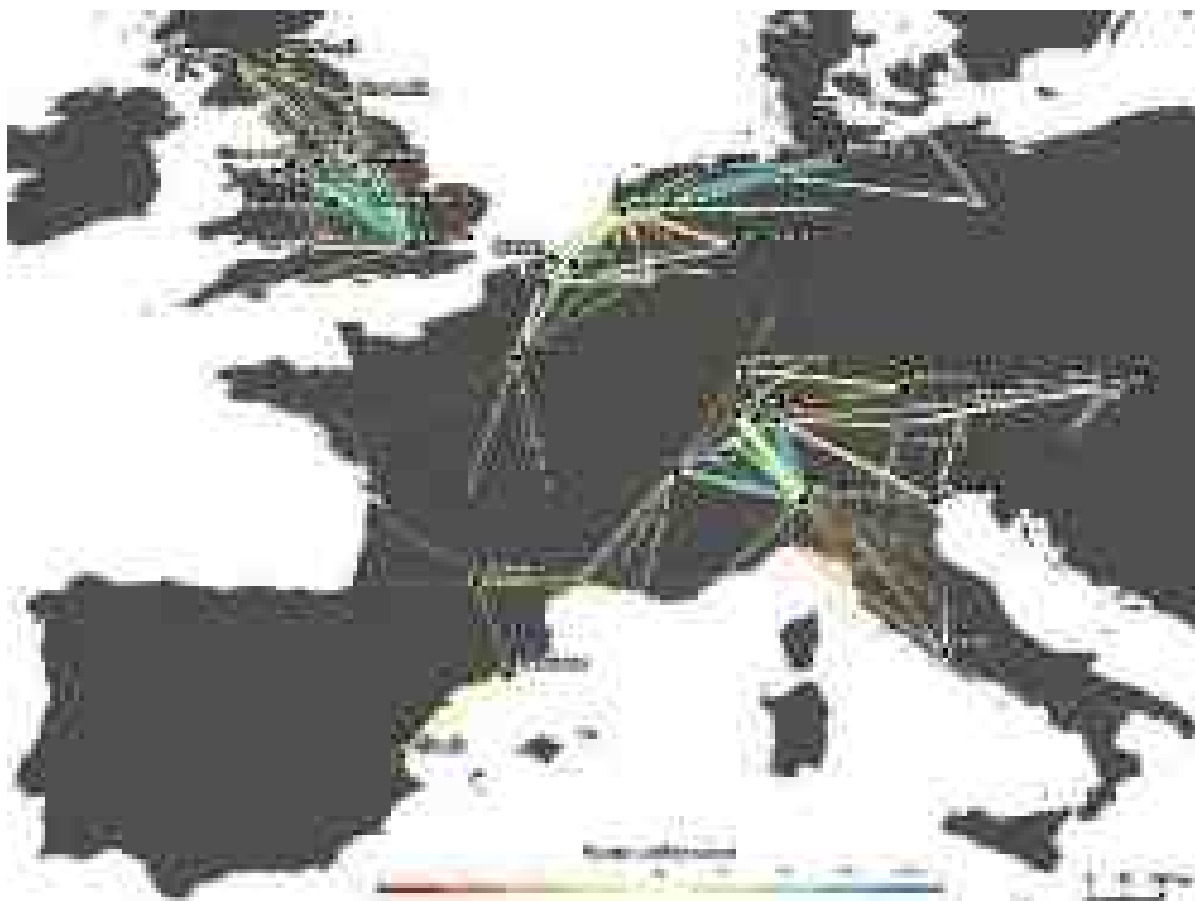


Figure 16. OD pairs, scenario 1 (IC competition).

Areas favourable for IC competition are relatively limited, particularly in Spain, France, and Germany. This is because, in these three countries, most long-distance traffic is high-speed rail HS⁷. In Spain, only

⁷ We classified German ICE trains as HS

one IC route—Barcelona–Valencia—stands out as relevant in terms of potential demand and is relatively favourable. In France, we identify minor and isolated OD pairs, along with some connections to Paris. The most promising markets are the UK, Italy, Benelux, and the Alpine region, where both higher potential demand and more favourable market conditions are expected. In the UK, traffic is heavily concentrated around London, though some cross-country lines—such as Leeds to Bristol and Cornwall—present interesting opportunities. However, non-London-centred OD pairs remain limited. An interesting corridor of OD pairs develops between Paris and Hamburg, well concentrated along a single route. Most passengers do not travel between the outer end points but instead to intermediate destinations such as Brugge, Gent, Amsterdam, and Brussels. Nevertheless, this corridor could potentially be offered as a continuous route. The third key area for IC competition is the Alpine region. Milan and Zurich emerge as primary hubs for this potential demand, benefiting from highly favourable conditions. Additional cities—such as Montpellier, Stuttgart, Vienna, and Florence—could also be connected.

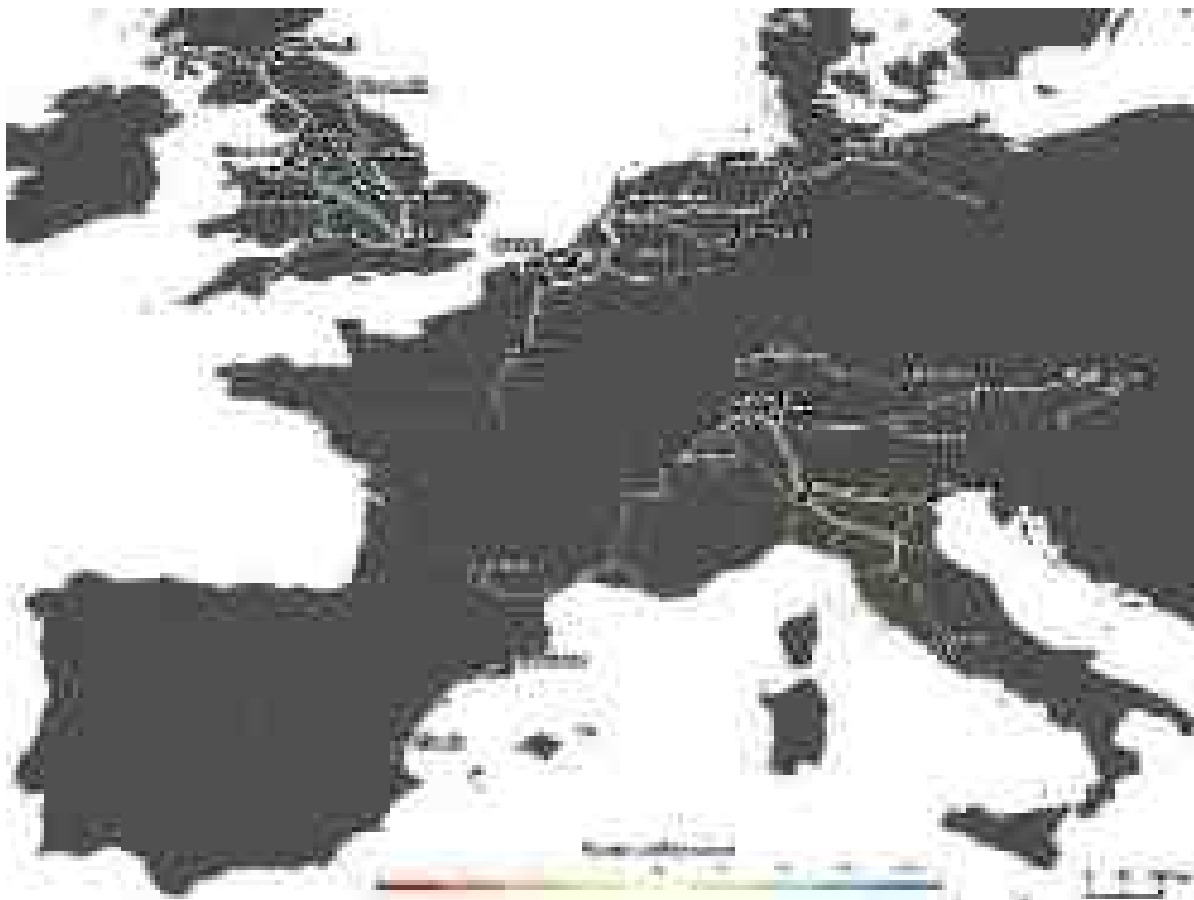


Figure 17. Corridors, scenario 1 (IC competition).

3.2 SCENARIO 2 – HS INTENSIVE “A LA COURNOT” COMPETITION

The scenario consists of two different sub-scenarios:

- **Scenario 2a**, describing the entry of a second operator on previously monopolistic routes. This can be exemplified by the entry of Italo in Italy in 2012: a new large competitor operating an intensive service, challenging the incumbent in a competition *à la Cournot*—focused on frequency rather than prices.
- **Scenario 2b**, describing market entry in the presence of two or more incumbents (whether as partners or direct competitors). An example is the current Italian situation, where two operators are active, and a third player is assumed to enter.

The filters applied to ODs are similar:

- ✓ Distance 100-800 km
- ✓ HS services commercial speed > 100km/h
- ✓ Presence of HS demand on the direct OD pair
 - ✓ 2a: No train competition
 - ✓ 2b: Any intramodal competition level

The first filter includes typical high-speed (HS) served pairs, ranging from 100 km to 800 km, approximately corresponding to 4–5 hours of travel. The second filter removes trains classified as HS but that, for certain OD pairs, are much slower (e.g. HS trains between Milan and Paris, which are not HS between Turin and Lyon). The final filter reproduces the previously described distinction between entry as a second or third operator.

Regarding the favourability indicators, Table 5 details the value set for both sub-scenarios. The first four describe the prices of competing operators (incumbent rail) and modes (air and coach) and are similar to Scenario 1: the higher and more dispersed the prices of trains, coaches, and aeroplanes, the richer the market for a competitor.

The fifth and sixth indicators represent demand for coaches and airlines. While the values differ from those in Scenario 1 to account for the different levels of price dispersion, the interpretation remains the same: *larger* markets are more favourable to a rail newcomer.

Finally, the last two indicators, which assess the competitiveness of rail—both in absolute terms and relative to air—function in the same way (the faster, the better), but speed thresholds have been adjusted to those of HS lines.

Table 5. Favourability parameters, scenario 2 (HS intensive competition)

bonus, prices	-3	-2	-1	1	2	3	
RAIL average price/km (2-seats)	-infinite	-0.75	-0.5	0	0.5	0.75	infinite
RAIL price variability (2-seats)	-infinite	-0.75	-0.5	0	0.5	0.75	infinite
SKY average price/km (2-seats)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH average price/km (2-seats)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH demand (2-seats)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
SKY supply (2-seats)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
RAIL speed	-infinite	100	120	140	160	180	infinite
SKY speed advantage to RAIL	-infinite	50	20	0	20	50	infinite

The results of the scenario are mapped in the following Figure 18 to Figure 21, representing respectively the ODs and the corridors for both sub-scenarios. The symbols are the same as Scenario 1.

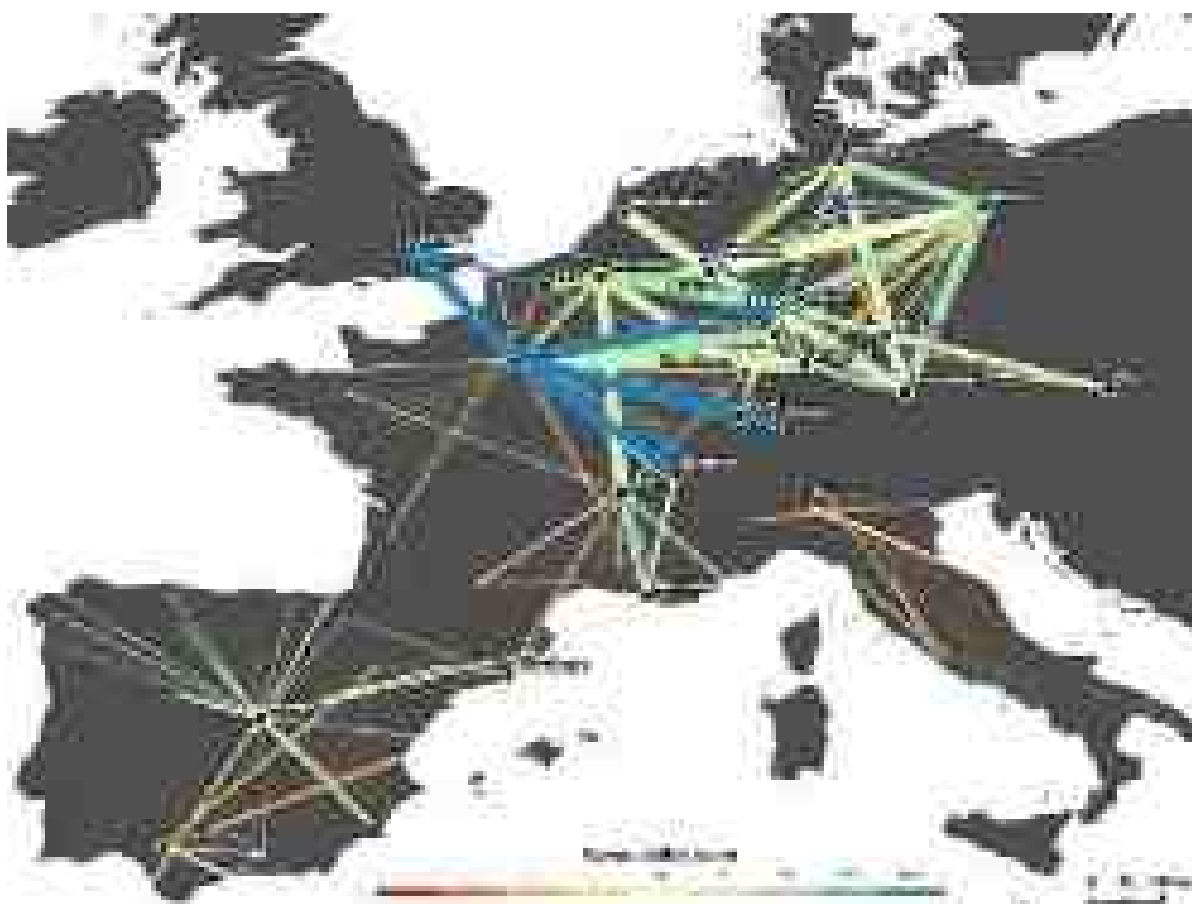


Figure 18. OD pairs, scenario 2a (HS intensive competition, 2nd player).



Figure 19. OD pairs, scenario 2b (HS intensive competition, 3rd player).

The combination of Scenario 2a and 2b covers the entire study area extensively. Scenario 2a is less dense in Italy and Spain because competition already exists on the main city pairs. In Spain, there is some potential north of Madrid and on a few minor OD pairs south of the capital (e.g. Valencia–Sevilla), but the favourability score is low due to intermodal competition and low prices from the incumbent. Italy is similar, but sparser, as Italo’s network is significantly more complete. The main remaining corridors for the first entry are Milan–Rimini–Ancona and something to Rome from Tuscany. All ODs have a very low favourability, making entry quite unlikely under the current conditions.⁸In Scenario 2b, the current competitive routes in Spain and Italy appear as thick and favourable, a sign that further competition on very crowded and competitive corridors is still possible.⁹



Figure 20. Corridors, scenario 2a (HS intensive competition, 2nd player).

The most attractive markets for first-time entrants are the whole of Germany and international connections between Paris and Germany and Switzerland. Many corridors are visible and could be explored by competitors, such as London – Paris – Zurich (but almost entirely made of Paris generated traffic) or Paris – Frankfurt – Hannover (in this case composed by many more OD pairs). Some long OD pairs are also possible, such as Frankfurt – Vienna.

France represents a peculiarity in this scenario. In our database we considered Ouigo as a “competitor” of InOui, even though both are managed by SNCF and represent a typical case of product differentiation. However, from the perspective of competitors, Ouigo is a second incumbent, with different pricing and different customer base. In these conditions, “new” routes for competitors are few, mainly Lille – Lyon and Lyon to various destinations in Southern France. Therefore, a possible line could operate between

⁸ e.g. south of Naples infrastructure investments are still ongoing, but when speed will increase, favourability will improve

⁹ Announced entries confirm this prediction, for example SNCF planning to enter in Italy as a third player.

the north of France and the very south, without serving Paris and maybe connected with Amsterdam/Brussels and London. For scenario 2b, the most promising lines for a third/ fourth player are, unsurprisingly, Amsterdam – Brussels – Paris and Paris – Lyon.



Figure 21. Corridors, scenario 2b (HS intensive competition, 3rd player).

3.3 SCENARIO 3 – BRAND-NEW SERVICES

In this case, the scenario is further detailed into two sub-scenarios.

- Scenario 3a, introduction of mid-long-distances brand-new services (that is: OD pairs without any direct rail connection), limited to HS or performing conventional lines. Candidates include any searched OD pair.
- Scenario 3b. Same, but OD candidates are only those with purchased tickets during 2023.

The filters applied are similar, but stricter conditions are used to reduce the routes of scenario 3a:

- ✓ Distance
 - ✓ 3a: 100-400 km
 - ✓ 3b: 100-500 km
- ✓ Commercial speed
 - ✓ 3a: > 80km/h
 - ✓ 3b: > 70km/h
- ✓ Absence of any direct connection
 - ✓ 3a: all searched OD pairs
 - ✓ 3b: purchased OD pairs only
- ✓ Score
 - ✓ 3a: min 20000 points (minor OD pairs excluded).

✓ 3b: any score

Concerning the **favourability** indicators, the following Table 6 details the value set for both sub-scenarios. In the absence of active connections, the first two indicators do not apply. With regards to air and coach prices, the usual rules apply: the higher the prices of competing coaches and aeroplanes, the richer the market for a competitor.

The value of the fifth indicator is reversed here: in the absence of current train options, we assume that the higher the coach demand, the stronger its position, making it more difficult for a new rail entry to compete. For the airline market, we applied the usual logic: the larger the demand to contest, the better it is. For speed indicators, the faster, the better, but with speed ranges that are more typical of fast conventional services rather than HS.

Table 6. Favourability parameters, scenario 3 (New services)

bonus/points	-3	-2	-1	1	2	3	
RAIL average price/km (z-score)							
RAIL price variability (z-score)							
SKY average price/km (z-score)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH average price/km (z-score)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH demand (z-score)	infinite	0.5	0.2	0	-0.2	-0.5	-infinite
SKY supply (z-score)	infinite	-0.5	-0.2	0	0.2	0.5	infinite
RAIL speed	infinite	70	80	100	120	140	infinite
SKY speed advantage vs RAIL	infinite	70	20	0	-20	-50	-infinite

The results of the scenario are mapped in the following to Figure 22 to Figure 25, representing respectively the ODs and the corridors for both sub-scenarios. The symbols are the same as Scenario 1.

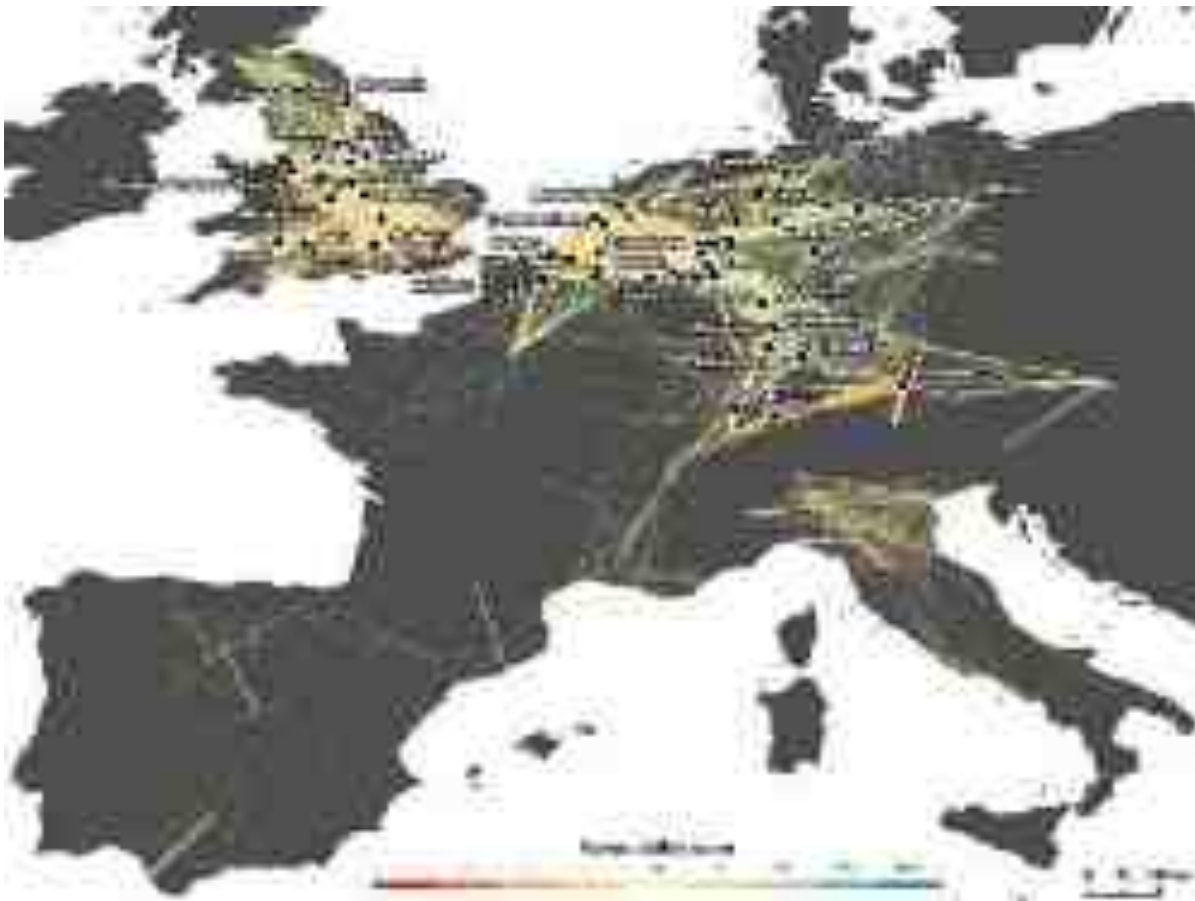


Figure 22. OD pairs, scenario 3a (Brand new services, all searched pairs).

Unserved but searched OD pairs are extremely numerous in Europe, with the largest ones concentrating mostly around Benelux and Western Germany. The reason is likely the existence of a complex network of cities and, at the same time, a rail network of services that relies more on interchanges than in other regions. In other words, when interchanges and connections work well and the system is based on them, the number of city pairs not directly connected is higher. Most of the searched ODs are instead very small in terms of potential demand, and probably only in a few cases might justify a dedicated service.

In addition, the most relevant OD pairs in terms of potential demand are "red", meaning that the competitive conditions are not favourable. Better favourability is found only for minor pairs. It is worth mentioning that Zurich–Munich was temporarily not operated at the moment of data extraction, but direct connections normally exist.

The map in Figure 23 is, on one hand, more selective (the OD pair must have been purchased during 2023) and, on the other, less selective (small OD scores are not excluded), and the parameters are slightly different. Ignoring the thin ODs, some differences appear, including among important cities in Southern Germany and Benelux (e.g. Munich–Basel or Hamburg–Amsterdam). In Italy and the UK, differently from France and Germany, we see many small OD pairs even among the purchased ones (Figure 23).

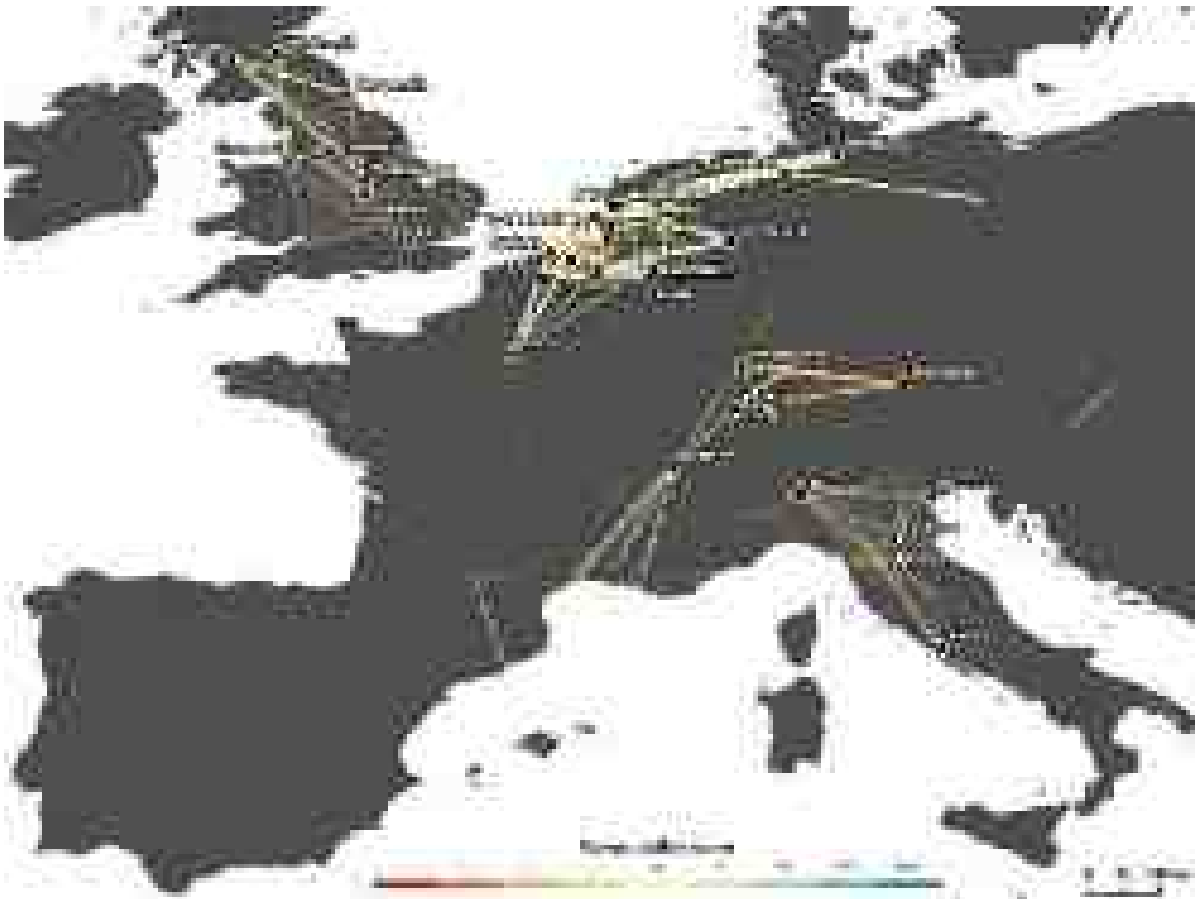


Figure 23. OD pairs, scenario 3b (Brand new services, purchased pairs only).

In some cases, the missing direct connection is with an airport, for example between Naples and Rome Fiumicino airport.

Once lines are assigned to the network, the geography of possible new lines gets clear, especially for the more selective scenario 3b (Figure 25). In general, it is clear that significant unexploited routes are few and are mainly international. A newcomer may introduce new services, but they will likely remain niche markets outside of the areas mentioned.

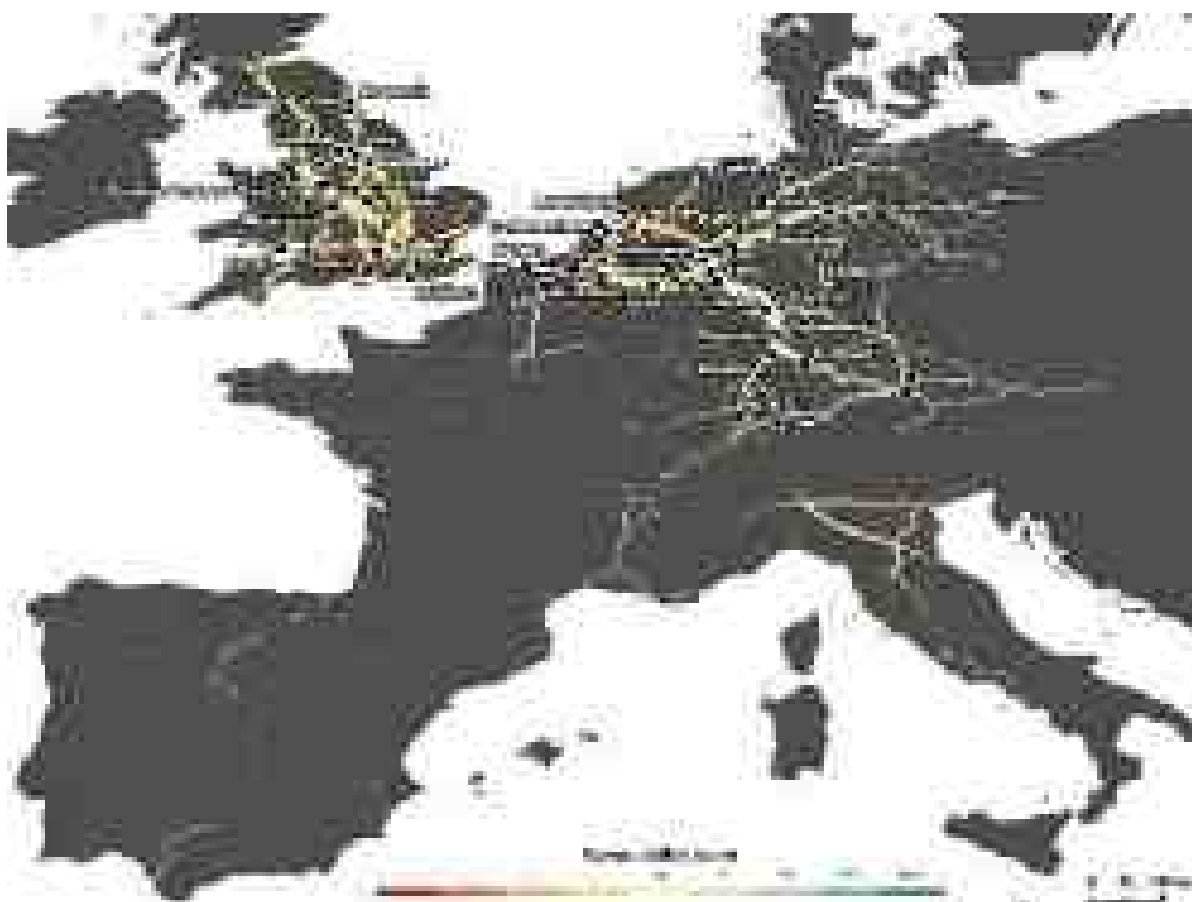


Figure 24. Corridors, scenario 3a (Brand new services, all searched pairs).



Figure 25. Corridors, scenario 3b (Brand new services, purchased pairs only).

3.4 SCENARIO 4 – NIGHT TRAINS

The scenario focuses on long OD pairs well-suited to be served by Night trains, typically in competition with air and night coaches. As long OD pairs are many and not clustered, but with low potential demand, we set **conditions** to reduce their number, in particular based on potential demand scores.

- ✓ Distance more than 600 km
- ✓ No HS on the same pair
- ✓ No rail competition already in place
- ✓ Searches score >20000 points to limit the results to actually demanded ODs

Concerning the **favourability** indicators, the following Table 7 details the values set.

The first four describe the prices of the competing operators (incumbent rail) and modes (air and coach) and are similar to Scenario 1 and 2: the higher and more spread (yield management) the prices of trains, coaches and planes, the more attractive is the market for a competitor.

The fifth and sixth indicators represent the coach and air demand. In this case, we assume a situation opposite to Scenario 1: the larger the competing markets are, the worse the score, because that means that fast (air) or cheap and night (coach) competitors already exist. Market night trains tend to be financially sustainable not as a low-cost service, but as more comfortable alternatives. Speed indicators are switched off, as speed is not a limiting factor for night trains.

Table 7. Favourability parameters, scenario 4 (Night trains competition)

bonus/points	-3	-2	-1	1	2	3	
RAIL average price/km (z-score)	-infinite	-0.75	-0.5	0	0.5	0.75	infinite
RAIL price variability (z-score)	-infinite	-0.75	-0.5	0	0.5	0.75	infinite
SKY average price/km (z-score)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH average price/km (z-score)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH demand (z-score)	infinite	0.5	0.2	0	-0.2	-0.5	-infinite
SKY supply (z-score)	infinite	0.5	0.2	0	-0.2	-0.5	-infinite
RAIL speed	infinite						infinite
SKY speed advantageous RAIL	infinite						infinite

The results of the scenario are mapped in Figure 26 and Figure 27, representing respectively the ODs and the corridors. The symbols are the same as Scenario 1.

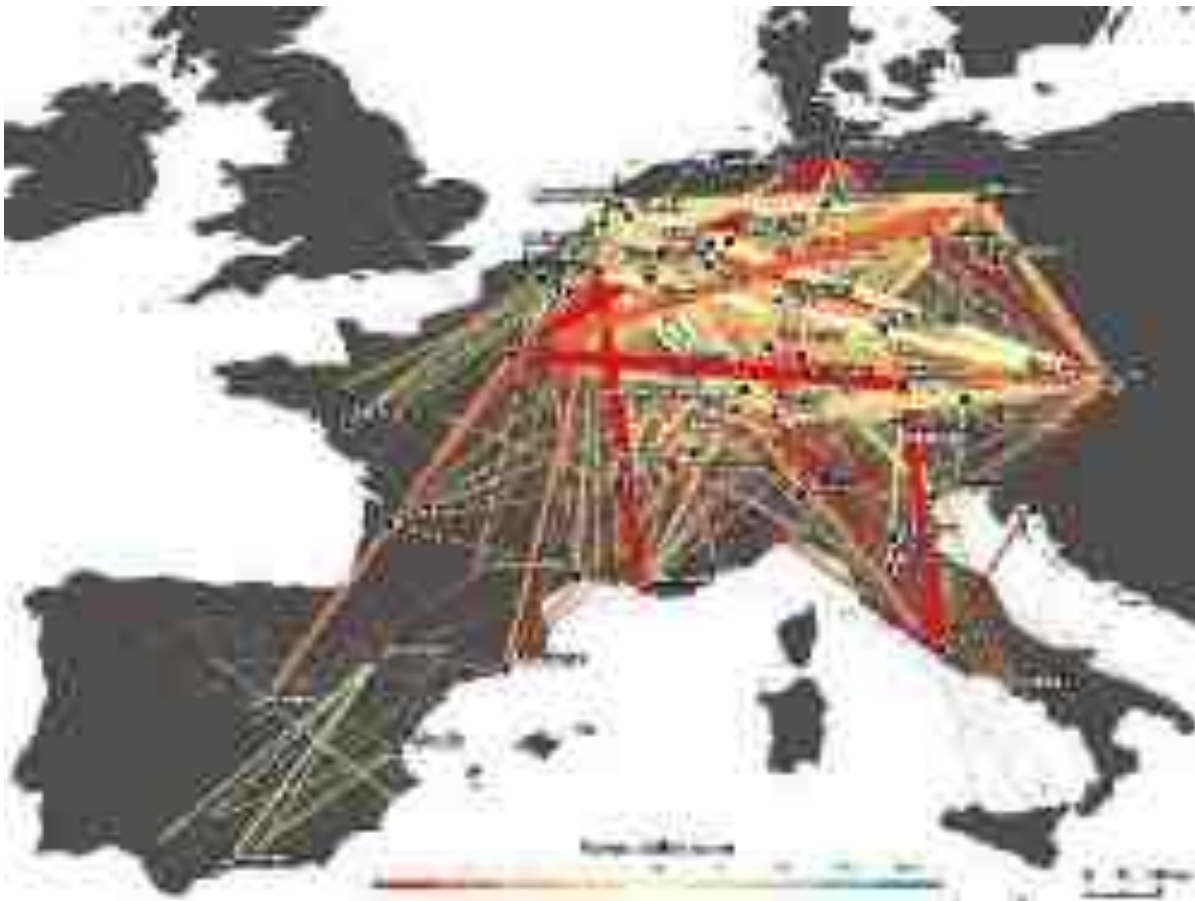


Figure 26. OD pairs, scenario 4 (Night trains competition).



Figure 27. Corridors, scenario 4 (Night trains competition).

What we observe is an extremely “crowded” map (the thickness scale is not constant across OD maps), full of potential connections, but all of them are “red”, meaning that conditions are generally not favourable. The reason is that competing coach supply already exists across the continent, and there is no price advantage for trains.

The resulting map of lines shows a similar pattern: even on crowded corridors, intermodal competition threatens market entries. Germany and France are, as usual, the largest unexploited markets, with potential connections extending south to Italy. Spain is isolated from the rest of Europe with relatively few lines, as the main corridors are already served by HS. The geography of the UK is not suited to this type of service, and ODs are excluded by the initial filters.

3.5 SCENARIO 5 – LOW-COST, NO-FRILLS COMPETITION

This scenario is designed to select OD pairs that are well-suited for the introduction of low-cost services, in competition with legacy services operated by incumbents.

The filtering conditions are set to exclude routes where rail prices (both monopolistic and duopolistic) are already low, as this would likely reduce the opportunity for a newcomer to further lower prices. This does not only apply to “efficient” incumbents, but also to cases of PSO-regulated prices. For the same reason, we exclude OD pairs with significant regional connections. We also focus on mid-distance routes, although in principle, low-cost services could also apply to trips longer than 500km. Finally, we exclude excessively slow cases, as cost reduction also derives from fast turnarounds of rolling stock and crews

- ✓ Distance 100-500 km
- ✓ Expensive rail (>15 €/cent/km, higher than the average)
- ✓ Commercial speed > 70km/h
- ✓ No or low regional traffic (<20%)

Concerning the favourability indicators, the following Table 8 details the value set.

Average price indicators (train, coach, and air) follow the previous rules: the higher the prices, the better for low-cost competitors, as this provides more flexibility to reduce prices in relation to the current equilibrium. The second indicator, that of price dispersion and yield management, has a reversed sign here: the lower the price variability today, the better for the newcomer, as they have the option to exercise yield management.

Concerning intermodal competition (5th and 6th indicators), the same rules from the previous scenario apply: the higher the demand for coaches and air, the stronger the competition, which disadvantages rail. Speed indicators work as usual: the faster, the better, with ranges typical of non-HS services. Of course, where speed is significantly higher, favourability improves, allowing for greater productivity.

Table 8. Favourability parameters, scenario 5 (Low-cost, No-frills competition)

bonus points	-3	-2	-1	1	2	3	
RAIL average price/km (2-score)	-infinite	-0,75	-0,5	0	0,5	0,75	infinite
RAIL price variability (2-score)	infinite	0,75	0,5	0	-0,5	-0,75	-infinite
SKY average price/km (2-score)	-infinite	-1	-0,5	0	0,5	1	infinite
COACH average price/km (2-score)	-infinite	-0,5	-0,2	0	0,2	0,5	infinite
COACH demand (2-score)	infinite	1	0,5	0	-0,5	-1	-infinite
SKY supply (2-score)	infinite	1	0,5	0	-0,5	-1	-infinite
RAIL speed	infinite	70	80	100	120	160	infinite
SKY speed advantage vs RAIL	infinite	50	20	0	20	50	infinite

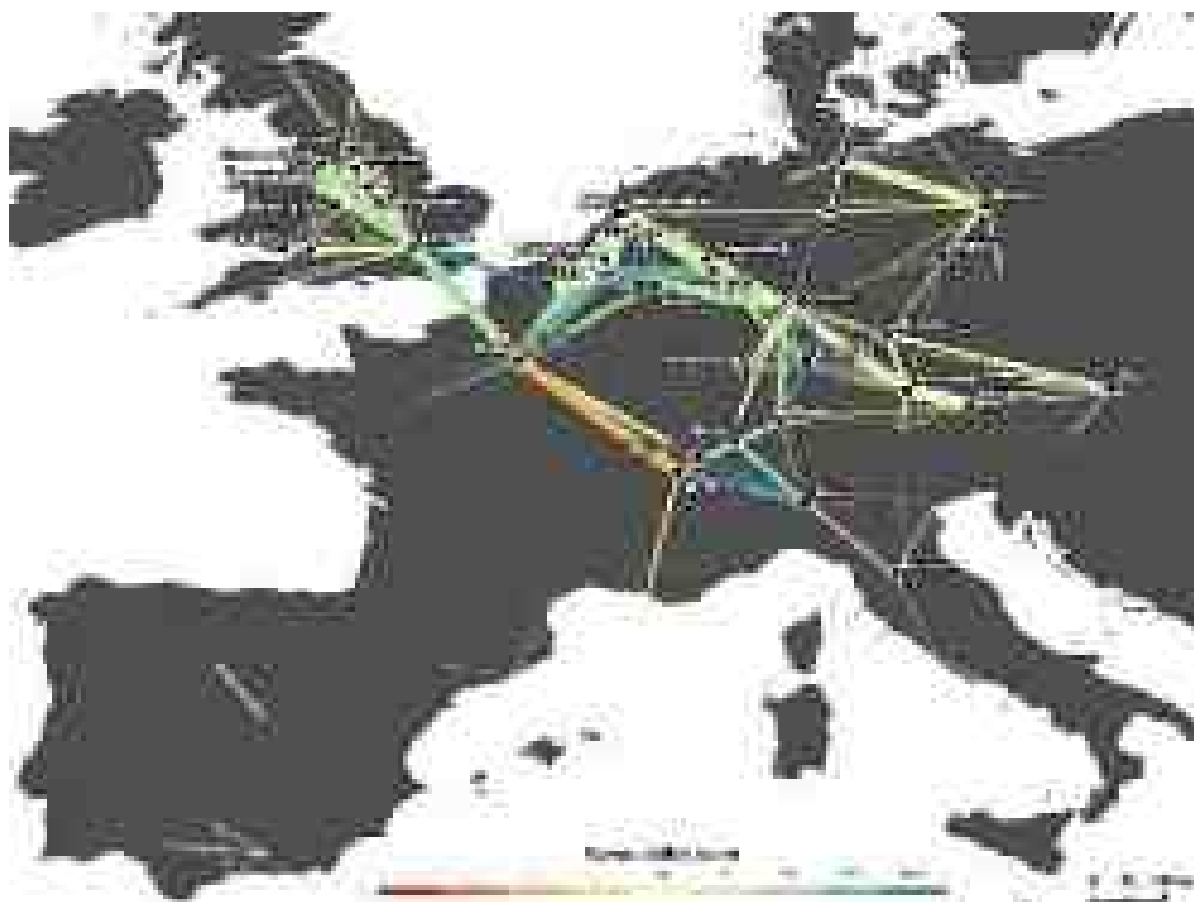


Figure 28. OD pairs, scenario 5 (Low-cost, No-frills competition).



Figure 29. Corridors, scenario 5 (Low-cost, No-frills competition).

ODs in Figure 28 are rather few, but thick: expensive routes are generally those with the most demand and a more performing railway system. Spain is empty, as in 2023 prices were very low thanks to competition. Italy is also rather empty, for the same reasons. The only interesting pairs are the Milan-Florence route and the international connections with Swiss cities. Western France is underrepresented due to the low speed of lines outside the high-speed network and low non-Paris demand.

The remaining markets are the most interesting for LCC: the UK, including the Channel Tunnel, Paris to Benelux, and some corridors in Germany and Netherlands. The most interesting one runs from Amsterdam to Munich and Vienna, connecting many mid-distance OD pairs and a couple of airports.

3.6 SCENARIO 6 – CROSS-BORDER CONNECTIONS

The scenario focuses on international cross-border OD pairs. International traffic is both the least developed in Europe and the area where most EU policies focus, both in terms of investment and regulation. The traditional cooperative model has clearly shown its pros and cons. The main advantage is that it makes financially sustainable low-traffic connections. Conversely, it has many limitations: it is not innovative, services tend to be very poorly performing and infrequent, and in general, it has all the characteristics of monopolies. In addition, collaboration among incumbents has proven very ineffective when it comes to ticket integration, often requiring multiple bookings for national legs of international connections. Competition – meaning the entry of a newcomer on previously incumbent-operated routes or new routes – is extremely positive for innovation and fare reduction, if financially sustainable (Beria et al., 2025). For this reason, the potential demand is extremely important, as well as the competitive framework, especially in relation to air and coach services.

To define this scenario, we set the following **conditions**: a broad distance span up to 800 km (where air transport becomes difficult to challenge both in terms of performance and costs) and a low commercial

speed (not to exclude numerous connections, which are currently operated by slow services). We excluded the few pairs where there is already competition, including the indirect ones, and filtered out low-potential connections to avoid background noise.

- ✓ Cross-border connections
- ✓ Distance 100-800 km
- ✓ Commercial speed > 60km/h
- ✓ Operated in monopoly, including indirectly
- ✓ Searches score >20000

Concerning the **favourability** indicators, the following Table 9 details the value set, which is similar to Scenario 1 (Intercity competition). Average price indicators (train, coach and air) provide an additional bonus if high, meaning that the market is potentially “rich”. The demand for competing modes has the opposite effect: the higher the demand already served by coach and air, the worse for rail. Rail speed factors are set as relatively low as the speed of current connections is low and lines often have poor performance. Below a commercial speed of 80 km/h, the indicator receives a malus, signalling that the productivity will penalise rail.

Table 9. Favourability parameters, scenario 6 (Cross-border connections)

bonus/punish	-3	-2	-1	1	2	3	
RAIL average price/km (2-score)	-infinite	-0.75	-0.5	0	0.5	0.75	infinite
RAIL price variability (2-score)	-infinite	-0.75	-0.5	0	0.5	0.75	infinite
SKY average price/km (2-score)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH average price/km (2-score)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH demand (2-score)	infinite	0.5	0.2	0	-0.2	-0.5	-infinite
SKY supply (2-score)	infinite	0.5	0.2	0	-0.2	-0.5	-infinite
RAIL speed	infinite	40	60	80	100	120	infinite
SKY speed advantage vs RAIL	infinite	-50	-20	0	20	50	infinite

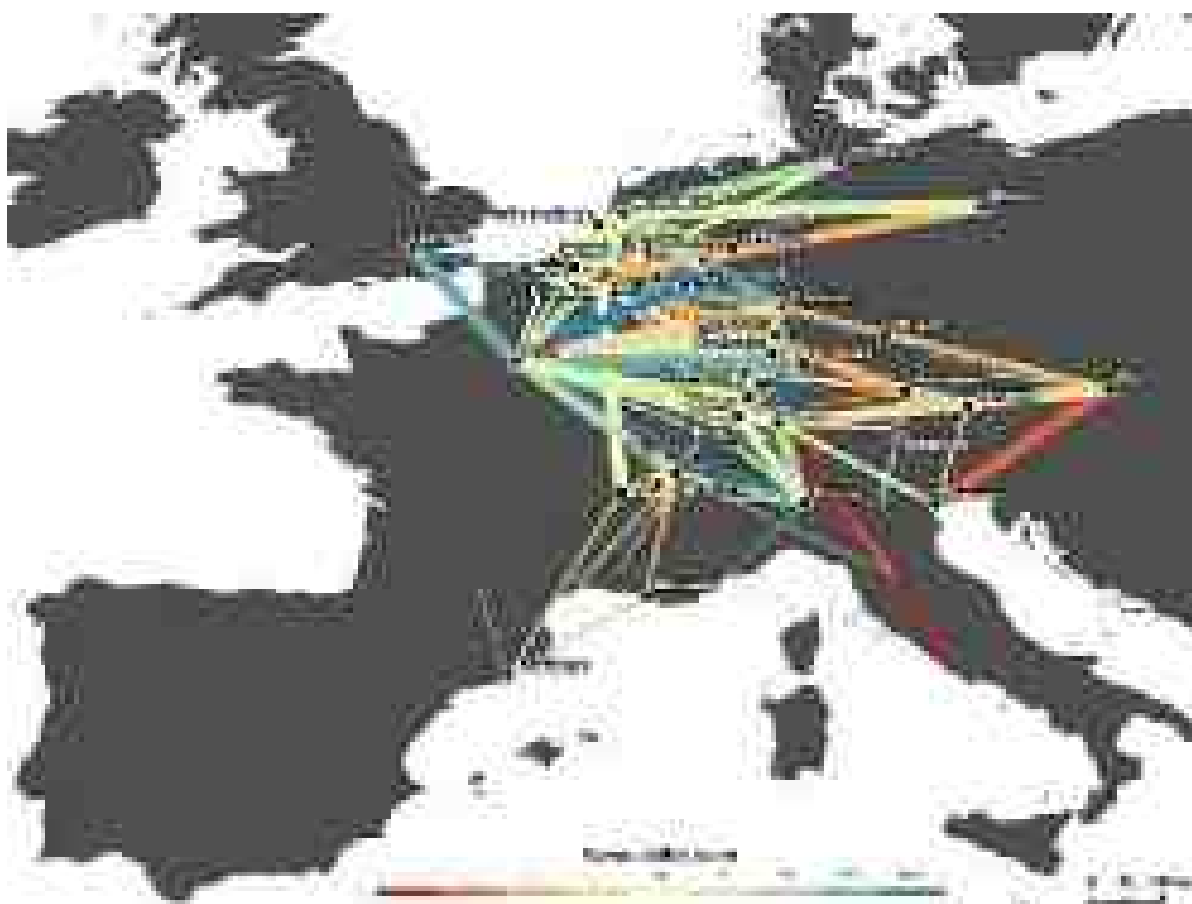


Figure 30. OD pairs, scenario 6 (Cross-border connections).



Figure 31. Corridors, scenario 6 (Cross-border connections).

ODs in Figure 30 are numerous but clearly clustered around the German borders. The main markets align with those present in the previous scenarios: Paris and the major cities of Western Germany, Belgium, and the Netherlands are the cores of international traffic potential. Extensions reach Berlin, Munich, and Austria, but their favourability is lower due to distance and speed disadvantages compared to air travel. Exceptions are few, and potential demand is lower: Milan, Switzerland, Lyon, and Venice are the main hubs. The only connection to Spain is between Barcelona and the south of France, which has been partially exploited in recent times.

Potential international corridors are those from Paris already mentioned and visible on the map in Figure 31. The only favourable corridors, apart from the northern one, are the Zurich/Geneva–Milan–Venice line, already served by SBB. Particularly interesting is the London–Lille–Paris corridor, as usual, given the very high prices and the speed advantage of trains, which today remain untouched by competition and with demand potentially much higher than the one estimated here, based on current price and capacity conditions.

3.7 SCENARIO 7 – AIR COMPETITION (SHIFT-TO-RAIL)

This scenario and the next one are not focused on competition, but on rail policies in general. They are based on the very same dataset and follow similar rules. The scenario focuses on OD pairs and lines where rail performance is competitive with air transport. Pairs are **selected** from those with existing direct air services and high commercial speeds, exceeding 100 km/h. Distances are capped at 800 km, as beyond this threshold, rail's contribution tends to be marginal with respect to air, also due to operating costs.

- ✓ Distance 200-800 km
- ✓ Commercial speed > 100km/h
- ✓ Presence of direct air services and demand

Favourability indicators (Table 10) do not consider rail prices, but just those of competing modes (the higher, the better). Concerning demand, significant demand from coach services is considered as a favourable condition as it can be challenged by new rail services. On the other hand, high air demand indicates that air is very competitive and difficult to challenge, partly due to the Mohring effect¹⁰ associated with high frequencies. Bonuses for rail speed are here set to be particularly stringent (e.g. +2 points above 130 km/h) because, if the speed is low, the likelihood of challenging air transport is minimal.

Table 10. Favourability parameters, scenario 7 (Opportunities for rail to challenge air transport)

bonus/points	-3	-2	-1	1	2	3	
RAIL average price/km (2-10000)							
RAIL price variability (2-10000)							
SKY average price/km (2-10000)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH average price/km (2-10000)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
ODACI demand (2-10000)	infinite	0.5	0.2	0	-0.2	-0.5	-infinite
SKY supply (2-10000)	infinite	-0.5	-0.2	0	0.2	0.5	infinite
RAIL speed	infinite	70	80	100	120	140	infinite
SKY speed advantage vs RAIL	infinite	20	20	0	-20	-50	infinite

¹⁰ The so-called “Mohring effect” (introduced in: Mohring, 1972) represents the decrease of waiting time (and thus the increase of users' welfare) due to the increase of demand, because of higher frequencies needed to serve it. The Mohring effect is a positive externality.

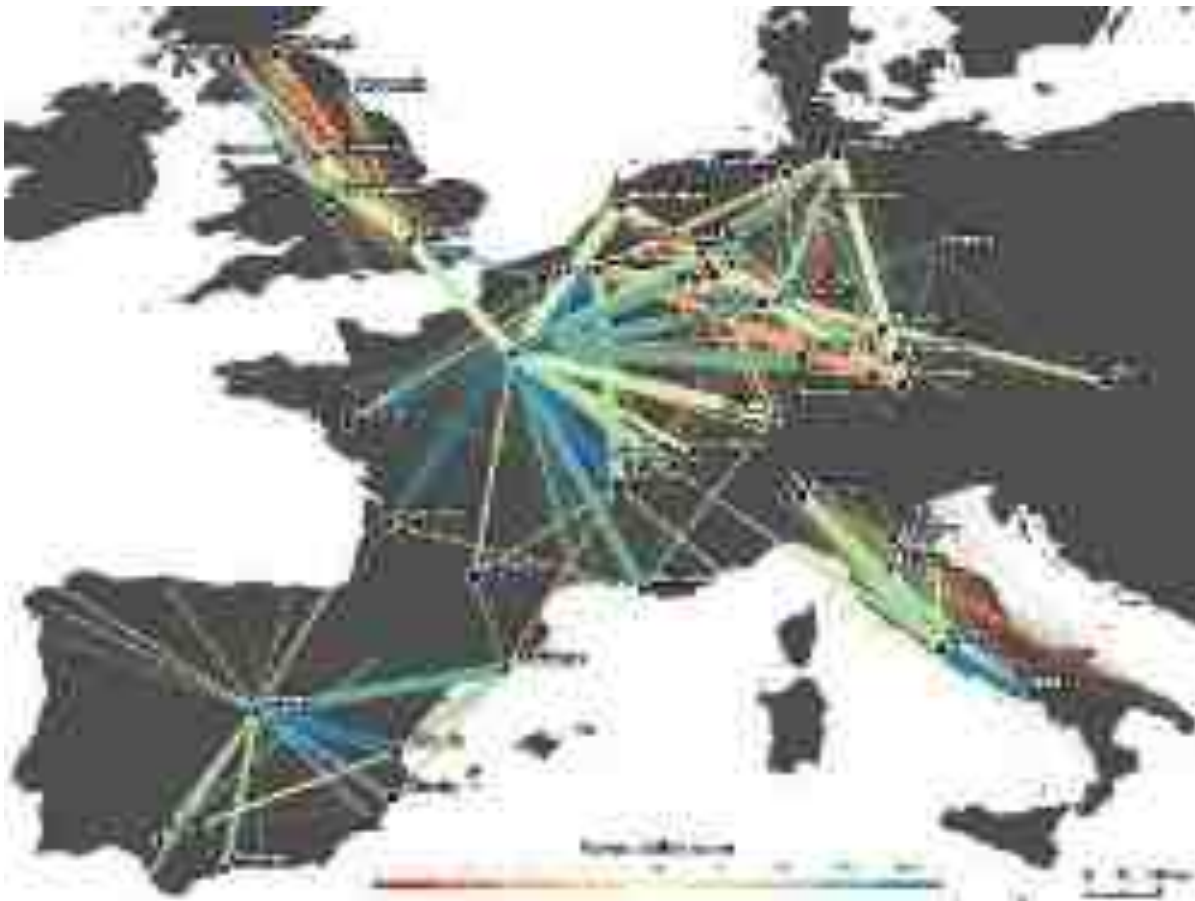


Figure 32. OD pairs, scenario 7 (Opportunities for rail to challenge air transport).



Figure 33. Corridors, scenario 7 (Opportunities for rail to challenge air transport).

OD pairs are numerous and are often associated with existing HS lines, though not exclusively. For example, in Italy, connections to the Adriatic coast (Pescara and Bari to Rome or Milan, for example) show very low potential demand and favourability. However, rail might be able to reduce dependency on air travel. In fact, these air connections (sometimes very short) only exist because rail is slow or there is no direct connection (e.g. Naples-Bari). Short-haul air routes are often used as feeders for long-haul flights, which keeps these routes active. However, they could be reconsidered with improved rail-air integration. In this sense, rail might be a good substitute for air travel not only on high-demand corridors, but also on low-demand ones. Competition, again, could be a driver for network innovation, especially on low-demand (but expensive) pairs.

Interestingly, our analysis identifies virtually no cross-border routes: speeds are too low, and performances are incomparable with air ones. Therefore, shift-to-rail policies should focus only on situations where the shift is currently feasible, rather than relying on *wishful thinking*.

3.8 SCENARIO 8 – WHERE TO UPGRADE INFRASTRUCTURE?

Finally, the last scenario examines OD pairs and corridors with both high potential demand and poor rail performance. These are the routes where investment policies should focus, as they serve the highest potential demand and would bring the highest benefits. In other words, where a Cost-Benefit Analysis would yield better results.

- ✓ Distance more than 100 km
- ✓ Commercial speed < 70 km/h
- ✓ Score >100000.

Favourability indicators (Table 11) do not consider current rail performance (7th and 8th indicator), assuming that the policy is going to improve today's baseline. For all other indicators, the principle of “the higher the better” is assumed: higher prices and price variability indicate a lively rail market and high air and coach prices - along with strong demand -, making infrastructure upgrades more attractive and justifiable.

Table 11. Favourability parameters, scenario 8 (Rail upgrades)

bonus points	-3	-2	-1	1	2	3	
RAIL average price/km (z-score)	-infinite	-0.75	-0.5	0	0.5	0.75	infinite
RAIL price variability (z-score)	-infinite	-0.75	-0.5	0	0.5	0.75	infinite
SKY average price/km (z-score)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH average price/km (z-score)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
COACH demand (z-score)	-infinite	-1	-0.5	0	0.5	1	infinite
SKY supply (z-score)	-infinite	-0.5	-0.2	0	0.2	0.5	infinite
RAIL speed	-infinite	0	0	0	0	0	infinite
SKY speed advantage vs RAIL	-infinite	0	0	0	0	0	infinite

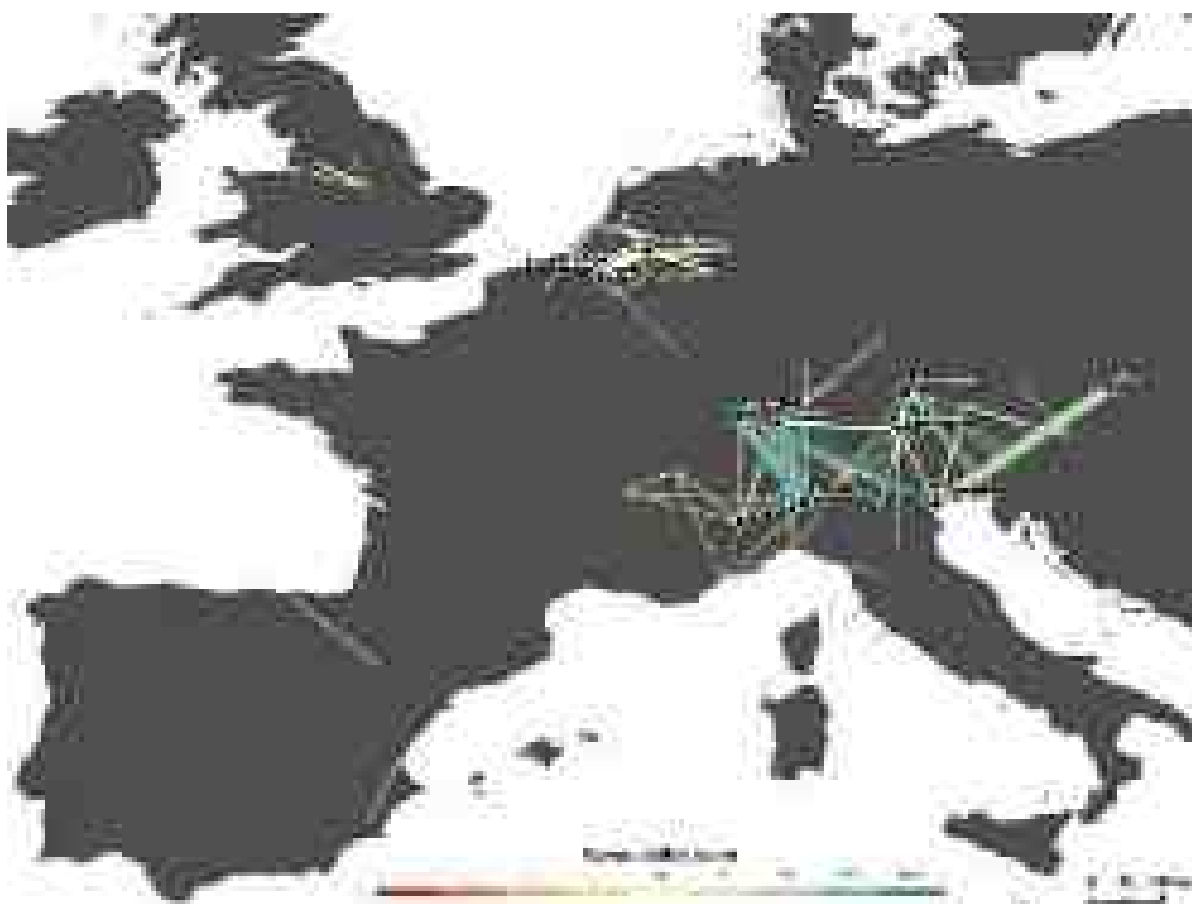


Figure 34. OD pairs, scenario 8 (Rail upgrades).



Figure 35. Corridors, scenario 8 (Rail upgrades).

The resulting maps of Figure 34 and Figure 35 are quite unexpected and therefore interesting. No high-demand corridor is – today – operated by particularly underperforming services, except all alpine crossings to Italy and some connections between Belgium and the Netherlands, which can, however, be classified as *regional* given the distances involved. Even more interesting: all “missing links” are already under construction except for Venice – Vienna: the Brenner basis tunnel and line, the Milan – Genova tunnel and line and the Turin – Lyon tunnel. The Zurich – Milan is already operational, but the fast line was closed during our data collection.

These results are very interesting from a policy perspective. All high-demand routes that either not currently operated or served by occasional services, could be supplied *tomorrow*, with the existing infrastructure. In this sense, the rise of competition is particularly promising as an innovation factor, stimulating demand. Large investments and high-speed lines can come later to improve performance and gain additional benefits, but intercity trains could be implemented right now in most cases.

4 GENERAL FINDINGS

In this section we provide a more **general overview of the open-access competition opportunities across Europe**. In the previous section we adopted the perspective of companies adopting a specific business model. Companies are not necessarily confined to a single model (although the size of competitors often limits their ability to vary models too much), and different business models may co-exist. We have various examples of different business models applied in the very same markets: for example, in Germany, Flixbus serves similar routes with a different level of service from DB; Ouigo in Spain, offers a no-frills version of the other two competitors.

Before mapping European competition opportunities (sections 4.2 and 4.3), we take a moment to clarify the limits of this study and of the related findings in the following section 4.1.

4.1 WHAT ELSE MATTERS?

Anticipating competition – especially across an entire continent – is a complex and multifaceted task that we have attempted to manage through some simplifications and assumptions. Additionally, our approach has been data-driven, aiming to make the very best of the vast information contained in an entire year of intermodal price and purchase observations, complemented by geographical and socio-economic data.

In this study, we examine three aspects determining competition opportunities:

1. **Geography**, in terms of uneven population and GDP distribution across Europe and characteristics of the networks.
2. **Potential demand**, merging an abstract component (a gravitational model on population and GDP) with an actual one (real searches), representing the market opportunities for a newcomer.
3. **Intermodal competition**, overlaying supply, price and performances of rail competing modes (air and coach), and representing the exogenous frictions to newcomers.

Conversely, we did *not* adequately model another four factors that do, in reality, have an influence:

4. **Costs**, including the **Train Access Charges (TACs)**: while the cost structure of a company is an endogenous variable, the TACs (and, to some extent, energy costs) are not. TACs are recognised as a favouring or limiting factor for competition (Montero et al., 2016; Montero, 2019; EC, 2024) and we observe across Europe a variety of examples, ranging from the marginal cost pricing in Central and Eastern Europe to the full cost recovery of French HS lines. The range of variability—broader on a line-by-line basis than the country averages documented by IRG RAIL (2024)—extends from a marginal portion of total costs to double or more. Needless to say, very high cost coverage protects taxpayers, but leads to higher ticket prices and may limit or even make head-on competition unsustainable (Álvarez-SanJaime et al., 2016; Beria et al., 2024). We briefly discuss the TAC as barriers in comments of Section 4.3.
5. **Capacity of lines**: second factor of crucial importance – a necessary but not sufficient condition for enabling competition – is the availability of capacity. While in many cases current networks have plenty of space for additional supply, in most successful corridors the demand is so high that capacity may reach a limit. Some examples of competition-saturated lines are the Italian HS line between Bologna and Rome or the Prague-Ostrava line in Czechia. Another interesting case can be found in Spain, where capacity was proactively allocated to competitors by the infrastructure manager to prevent saturation. An additional element determining capacity constraints is more policy-driven: the adoption of **strictly regular timetabling**, coordinating long-distance and regional trains. While this is certainly beneficial for travellers, a fixed timetable may simply not allow the inclusion of trains that are out of the “Taktfahrplan” structure. When capacity is

insufficient (either actually or artificially), competition cannot thrive even if the other conditions are ideal.

6. Concerning capacity, our analysis also ignored a third element: ongoing **network improvements** and future projects. The analysis is based on the current performance of services (particularly travel times), but in some cases, in the near future, conditions will radically change thanks to ongoing projects. A notable example is the Rome-Bari line, which currently shows very limited potential and a low favourability score (Figure 24 or Figure 33) due to its low speed, as well as the strength of the air and coach alternatives. However, a new HS line is under construction, which will increase the potential demand score (by reducing travel time impedance) and enhance the favourability score (by making coach and plane less convenient). Both conditions will improve the prospects for competition.
7. A final element is not included in the analysis: the **presence of other specific barriers**, such as market power or de facto monopolies. For example, in Czechia, Slovakia (Tomeš et al., 2022) and Spain, free regional transport for large segments of population restricts the opportunities for open-access competitors beyond the main and most performing lines. Similarly, the lack of integration with regional lines when operated by the incumbent, poses an additional challenge.

For these reasons, our study **cannot be seen as a forecast**, but as a **geography of potential opportunities**.

4.2 THE OVERALL COMPETITIVE LANDSCAPE IN EUROPE

The scenarios in section 3 reflect promising markets for *one* operator adopting *one* specific business model. However, from a policy point of view, it is more important to consider **how the entire EU competitive environment might evolve**, as multiple companies adopting different business models simultaneously may enter the market. To address this, we overlay some of the previous scenarios, when they are mutually compatible.

A first case considers the integration of the three main business models: conventional IC, HS and low-cost, starting from a currently monopolistic situation (**1 U 2a U 5**). We exclude here the option of a third non-low-cost player, given the financial sustainability challenges posed by intense competition model (Beria et al., 2025).

The intensity of the potential demand in this scenario (Figure 36) is **not uniform**, because competition is already present (Italy and Spain) or because the market is less promising (low-population or remote areas). Nevertheless, **there is still room for competition nearly everywhere in Europe**. Germany and France-CH/DE areas are the most promising ones for competition (in terms of both market size and feasibility), but interestingly, Italian and Spanish markets, despite already being highly competitive, still have room for *further* competition, primarily under a low-cost model, but to some extent also with conventional IC trains.



Figure 36. Corridors, scenario 1 U 2a U 5 (Overall European market for 2nd operators, including low-cost).

The second case (Figure 37) represents the overall EU market for non-low-cost players. In this case we also include the possibility for a 3rd operator challenging a duopoly but exclude the low-cost model, as it would partially overlap (1 U 2a U 2b). The main differences can be found in Italy, but also in Spain on the duopolistic pairs and in France¹¹ from Paris to the Atlantic coast. The possibility of a 3rd entry is, in fact, **not necessarily far away** with demand and margins are potentially high. This already occurred in the Spanish market and the Italian announcement of SNCF entry goes in the same direction. Notably, the effects on prices (higher) and financial sustainability (harder) would be completely different from duopolies.

¹¹ Here we consider Ouigo as a third player, because of its very different characteristics and customer base.

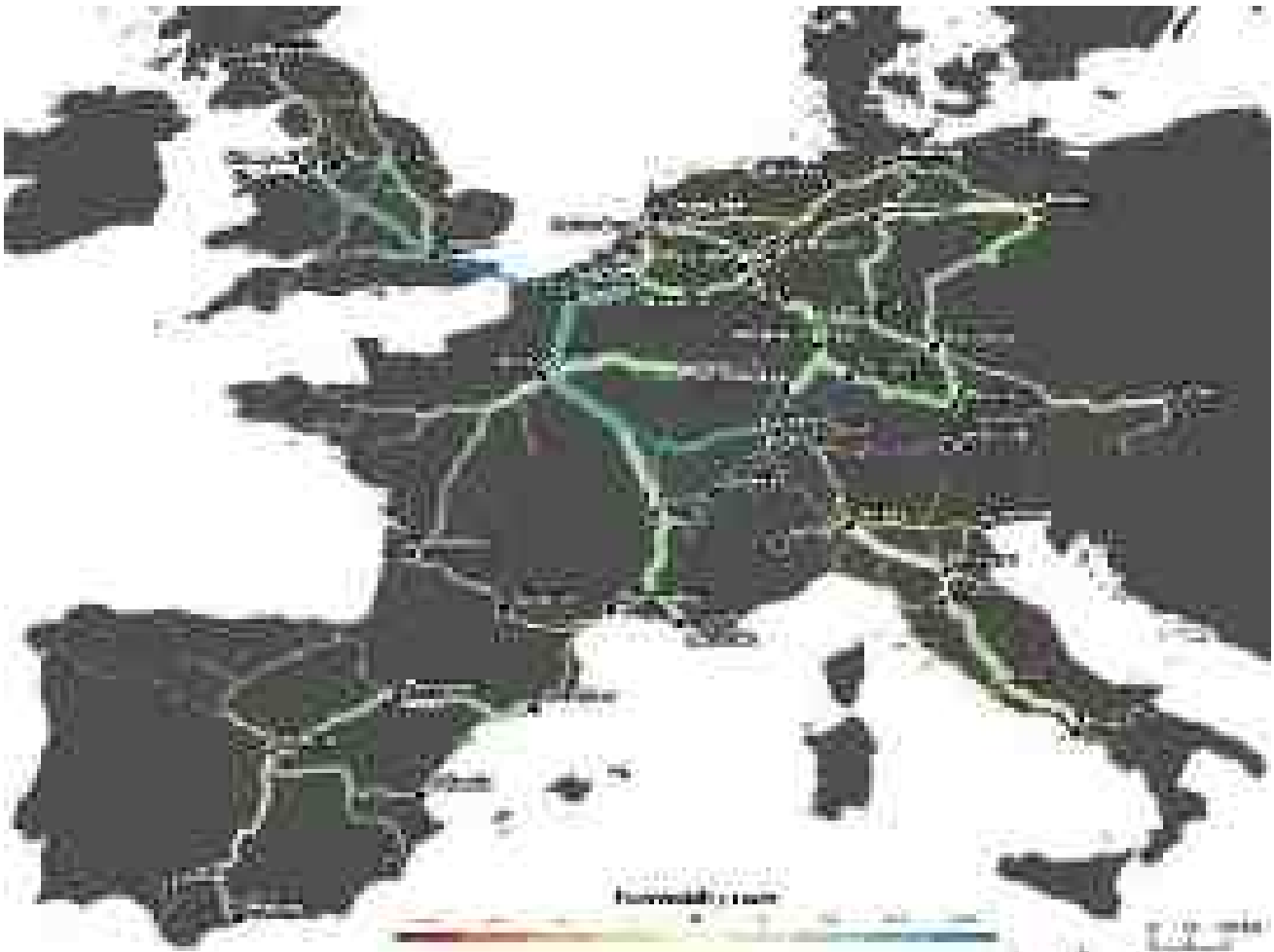


Figure 37. Corridors, scenario 1 U 2a U 2b (Overall European market, including 3rd entries, but excluding low-cost).

A third composed scenario is created to address the question: **where can competition drive modal shift from air travel?** To do so, we intersect routes that are suitable to shift-to-rail (scenario 7), with those where competition could emerge in some form (1 U 2a U 5).

Results are in Figure 38. The **highest potential for shift is, again, concentrated between France and Germany**, because of the presence of an important short-haul air market. Other corridors exist in Italy and Spain, even if competition (and HS) has *already* promoted the shift in the past, leading to the reduction of many formerly important air routes. In the UK, sufficiently long and fast OD pairs are fewer, but still significant.

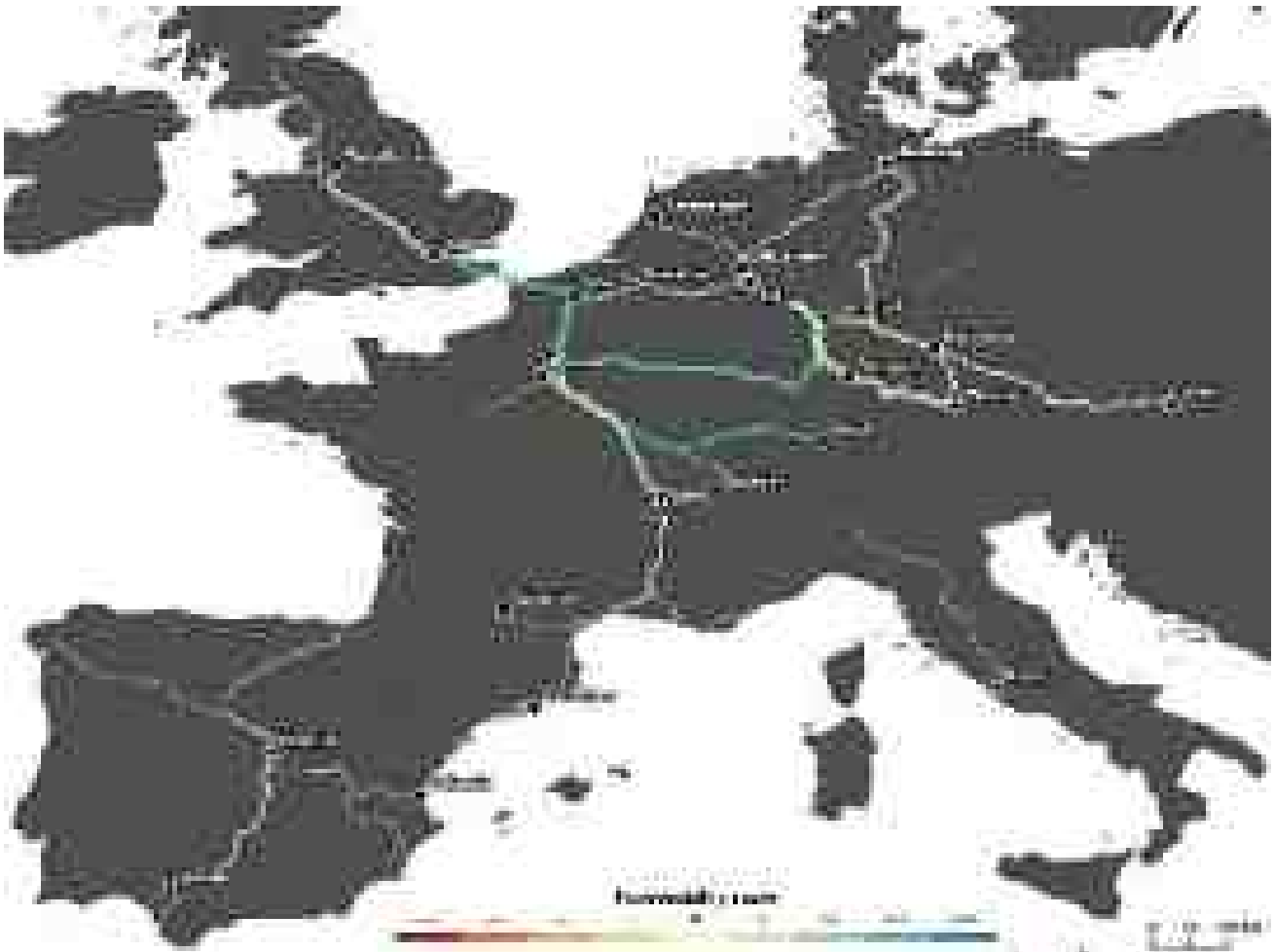


Figure 38. Corridors, scenario 7 $\cap$ (1 $\cup$ 2a $\cup$ 5) (Where competition can push modal shift form air to rail?).

In conclusion, which rail corridors could be the most promising ones for competition in Europe? Table 12 lists some of the most promising ones. These are clearly just examples, as corridors often overlap and many combinations are possible, especially in France/ Germany. For example, the Paris-Basel-Zurich corridor could also pass through Geneva or be extended to Milan or Lille. The Berlin-Cologne route is also just a suggestion connecting cities with potential demand among them, but not necessarily much between the extremities.¹²

While our Table 12 is merely suggestive, it is significant that in numerous cases (last column) we have evidence of newcomers and announced entries.

¹² The recently opened Berlin-Paris direct connection is a good example: there is clearly sufficient demand between the two capitals to justify a handful of direct trains per day. However, a thick line on the above maps represents a demand for *many* trains per day, similarly to what we have seen in the cases of “intensive competition” typical of high-density domestic corridors. For this reason, the traffic between intermediate cities is necessary to sustain this kind of services, especially when commercial speed is not that of a HS line.

Table 12. Example of most promising corridors in Europe for direct competition, according to business model.

<i>Corridor</i>	<i>Countries</i>	<i>Business Model(s)</i>	<i>Favorability</i>	<i>Planned</i>
London – Lille – Paris	 , 	1, 4, 7	very high	Evolyn, Virgin Trains, Kevin Speed (Paris to Lille)
Paris – Geneve/Basel – Zurich	 , 	1, 7	very high	
Paris – Brussels – Amsterdam	 ,  , 	1, 2, 3, 4, 7	high	Heuro
Brussels – Paris – South France	 , 	1, 4, 7	high	Renfe (Paris to South France)
Manchester/Liverpool – London		1, 7	high	
Milan – Rome – Naples		1, 2, 4, 7	good	SNCF (HS), ArenaWays (conventional)
Barcelona – Madrid – Seville		1, 7	good	Ouigo
Berlin – Hamburg/Hannover – Cologne		1	good	
Frankfurt – Strasburg – Paris	 , 	1, 7	good	Kevin Speed (Paris to Strasbourg)
Munich – Stuttgart – Amsterdam	 , 	1, 4, 7	good	WestBahn (recently serving Munich to Stuttgart)

Business models: 1. High Speed Competition (à la Cournot), 2. Intercity Competition, 3. Cross-border competition, 4. Low-cost, no-frills competition, 5. New services, 6. Night trains, 7. Air competition.

4.3 COUNTRY CONCLUSIONS

The previous analyses have shown that significant differences exist among the countries analysed in terms of actual competition, network status, types of services (e.g., focus on interchanges or not), presence of HS, urban structure, etc. These differences lead to very distinct competitive landscapes: while competition may be desirable nearly everywhere, the way it is deployed depends highly on the country and area. In this section, we summarise the findings on a country-by-country basis, rather than by market model.

Italy stands out as the country with the highest level of competition, both in terms of market size for newcomers and territorial coverage.

Nevertheless, there is still room for new entries:

- a. IC on all main corridors;
- b. Cross-border across Alps towards CH and DE, less to FR and AT;
- c. A 3rd HS player, but mostly between Milan/ Venice and Rome, less likely on network fringes;
- d. Brand-new services almost everywhere, but on small-demand routes (so, unlikely);
- e. Low-performance connections only across Alps and already under upgrade.

While Italian **TACs** will remain low compared to total costs and European peers, a major barrier to further competition is the limited spare **capacity** at key nodes and on some main corridors, particularly the HS one. This scarcity is expected to be only partially alleviated in the coming years through ongoing investments, meaning it will continue to be a barrier to entry in some cases. Increasing train capacity will soon become necessary, even though the business models of the two current competitors have, up to now, focused on increasing frequency.

The presence of competition in **France** is still limited and recent. However, the French market is one of the richest, and the network and territorial configuration are well-suited to rail. The most promising submarkets are:

- a. Limited room for IC competition, primarily towards Paris.
- b. Extremely promising for international services, both conventional (to Amsterdam and Hanseatic cities) and HS (to CH and London, most favourable), but also to the entirety of Germany, where there is high potential demand.
- c. A third competitor, effectively a second given SNCF's control over Ouigo and Eurostar, would find extremely favourable conditions on the main corridor Bordeaux/Sud-Paris-Lille-Bruxelles-Amsterdam.
- d. Low-cost competitors can be expected only on cross-border services, due to the barrier posed by Ouigo's presence.
- e. The potential for air traffic substitution is high, both domestically and towards Germany.

While the network and geography are favourable, two major barriers exist: very high **TACs** and the presence of **Ouigo**, which significantly lowers unit revenues for competitors.

The most intensive competition in Western Europe is currently on main lines in Spain. However, the lower demand density in the country limits the opportunities for widespread competition. In particular, we found:

- a. Limited room for the IC competition model (due to the low performance of the non-HS network), as well as for new services, low-cost, and cross-border services.
- b. HS competition north of Madrid is possible, but the demand density remains low.
- c. There is significant potential for airline substitution on all HS corridors.

Barriers to *further* competition in Spain are structural and relate to the country's peculiar **geography** (isolation and sparse population). Theoretically, the slot allocation model used thus far is not a barrier to new entries, as there is a stock of unallocated capacity available to newcomers.

The most promising market for open-access competition appears to be in Germany, not only because it remains largely unexploited, but also because of its geographical characteristics: a network of large and mid-sized cities, many of which are currently not directly connected, supported by effective regional feeders from the respective catchment areas. In summary, our expectations for the German market are:

- a. Some room for the conventional IC model, especially for cross-border services with France, and to a more limited extent with Austria.

- b. Significant potential for intensive competition on fast services, covering most of the country, including extensions to Paris and London.
- c. Potential for brand-new routes, mainly concentrated along the Rhine valley, but also extending eastwards.
- d. Many night-train options, including cross-border services to France, Vienna, and Italy, though with a low degree of intermodal competitiveness.

Barriers do exist, as such a large market currently has only one main competitor (Flixbus), plus Westbahn, both of which are expanding slowly. The main barriers lie in the scarcity of capacity (as well as the rules for **capacity allocation**) and in the conflictual interaction with **DB's clockface timetables**.

The **UK's** regulatory specificities set it apart from other examples. From the perspective of territory and networks, open-access competition appears to have potential in:

- a. IC connections, especially along about two-thirds of the main corridors and some cross-country routes.
- b. Sparse and limited opportunities for brand-new services.
- c. Attractive conditions (demand and intermodal markets) for low-cost competition, particularly on a few key corridors.
- d. Cross-border services remain very promising, primarily towards Paris and Lille, which serve as gateways to continental Europe.
- e. Limited potential for airline substitution, particularly from Scotland and to Paris.

The existing franchising system is not always compatible with open-access, making some of the above scenarios more abstract. However, this may change with the announced re-nationalisation.

The potential competitive landscape in smaller countries (**Switzerland, Austria, the Netherlands, Belgium**) is clearly more oriented towards cross-border services, which are often underdeveloped and operated under monopoly or agreement conditions.

- a. Lacking HS lines, competition focuses primarily on the conventional network, including both West-East (Paris-Hamburg and Geneva-Vienna corridors) and North-South (Switzerland-Italy) routes.
- b. The corridor Amsterdam-Rotterdam-Brussels-Lille-Paris is particularly well-suited for intensive HS competition.
- c. New services could be proposed, particularly from Flanders.
- d. All these countries could present opportunities for night-train competition.
- e. There is limited potential for air-train substitution, except to/from Amsterdam and Brussels.

The main barriers, apart from the **market power** of incumbents, are specific to **Switzerland**, where open-access is not permitted.

5 CONCLUSIONS

Our study has focused on where and under which business model open-access competition can develop in a selection of European countries. We have shown that there is significant **potential** for new entries in the European rail market, provided that sufficient capacity, the right competitive environment, and a **level playing field** are guaranteed. **Competition has proven beneficial for passengers** (more trains, higher quality, lower prices, new connections), for the **environment** (more passengers, modal shift), and for **collective welfare** (economic efficiency, territorial connectivity).

However, competition is **not always financially sustainable**. The single rail market is anything but homogeneous: geography, economy, network, intermodal competition, and regulations differ across European regions. To be sustainable, **the right business model must be adopted to better leverage the characteristics of each market**.

The correct strategies from different market actors are necessary, but they are not sufficient conditions for entry. Informed, wise, and effective **public policies** are crucial, including:

- ✓ Market regulation
 - ✓ Removal of residual entry barriers
 - ✓ Promotion of a rolling stock market, including effective secondary markets
 - ✓ Guarantee of availability of a wide range of sales channels
- ✓ Capacity regulation
 - ✓ Guarantee of access to the network
 - ✓ Control of oversupply
 - ✓ Management of conflicts with regular timetables
- ✓ A balanced policy on Network Access Charges
- ✓ (Sometimes) investments in the physical network
 - ✓ To increase capacity
 - ✓ To increase performances.

We believe that all these ingredients, together, can sustain healthy and beneficial competition across the entire European continent, in line with decarbonisation and economic efficiency goals.