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Research paper

Long-distance rail in Europe: Comparing the forms of head-on competition across Europe

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ABSTRACT

Europe is finally entering a season of liberalisation in the long-distance rail passenger market, which takes the form of on-track competition among public and private operators. The paper provides a broad-scope comparison of relevant European markets, belonging to liberalised and non-liberalised countries, aiming to point out the patterns in terms of supply, competition model and prices. The paper is based on a sample of heterogeneous 69 city-pairs, analysed in two fourteen days periods in 2019 (May/June and November). All available modes are observed, collecting info on companies, frequency of services, and cheapest price. The analysis starts from a schematisation of different business models, based on literature. Then, using the database, we study the country's supply structure, size, and level of intermodal and intra-modal competition through HHIs. Prices are analysed in two steps: the average prices and the price dispersion, searching for their main determinants, including but not limited to competition. Results show that a higher competition level is not always corresponding to low prices, which are instead determined by many other factors such as size of market, demand, socio-economic characteristics, subsidies, production costs, speed advantage, strength of the incumbent, etc. The competition level, instead, directly influences the quality, the supplied capacity, and the price dispersion.

1. Introduction

Liberalisation of the transport markets is a widely discussed theme, especially in the air and bus industries. In the previous decade, liberalisation also came to the long-distance railway market, at least in some countries, but with very different natures of competition and with apparently different outcomes across countries.[1] The phenomenon of railway market liberalisation nowadays is getting more emphasis in the EU as many new markets and routes are open or will be opened to competition. The relevant research usually focuses on intramodal competition or on the effect of an intermodal entry, but not on overall multimodal market equilibria. Empirical contributions, moreover, tend to look at price determinants of a single case, losing the generality that a cross-market comparison would give. In fact, these studies are usually geographically limited to one country case or only a few route cases (see in Literature review in Section 2). There is not yet a general vision of intercity rail competition in Europe, that still *seems* a patchwork of heterogeneous experiences.

Our motivation within this paper lies in the need for a more broad and general description of how rail competition shapes the markets. The assumption that every case is a story by its own can last until competitors are few, small and local. But the expectation – and recent movements confirm it – is that also big players will soon start playing in foreign fields, and that small early-entrants are merging and expanding. Then, in this paper we aim at providing, for the first time, quantitative elements characterising the EU intercity rail market as a whole, to ground a general taxonomy of the models of head-on competition.

Our research starts from an extensive effort to create a new dataset covering both multimodal supply and price information, and using it to analyse the forms of competition currently in place. The database

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[1] Authors' contribution to the paper are as follows. All authors contributed to the design of the database and to the research design. Michal Kvasnička has created the automatic procedures and data structuring. Samuel Tolentino has designed the database and the cleaning procedure. The analysis of data has been performed by Paolo Beria, Vardhman Lunkar and Vilém Pařil. The text has been written primarily by Paolo Beria and Vardhman Lunkar.

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consists of many routes (69) geographically spread over the entire continent and not limited to mainlines, capable of covering all relevant competition cases, including future ones. Thanks to this dataset, we will provide an assessment of companies' business strategies in relation with the competitive environment, focusing on prices of intercity long-distance connections in large part of Europe. We decided to look at the situation of 2019, representing a frozen picture of the situation before the changes due to the 2020-2021 COVID crisis. The large perimeter of the database allows for conveying much more robust results than what would have been possible by taking just a handful of specific case studies. Moreover, while the focus remains on trains, intermodal competition can be controlled and discussed.

The paper has been structured as follows. Section 2 introduces literature on competition in transport markets. Section 3 describes data collection, cleaning and preparation for analysis and introduces the method used to assess the level of competition. Section 4 presents the background for the studied markets and their relevant transport market specification. Section 5 collects the main results of our analysis, describing how companies behave in terms of supply definition and price strategies. Section 6 draws up results and proposes a general interpretative scheme of rail newcomers strategies, with the aim of making the heterogeneous cases observed across EU finally comparable. Section 7 concludes and discusses the limits of the work and future research developments.

2. Background and literature review

Open access on-track competition is one of the possible liberalisation approaches in the heterogeneous long-distance passenger rail market (Finger, 2014), together with the franchise approach (Wheat et al., 2018), intermediate forms of duopolies (Montero et al., 2016) and asymmetric regulation (Bougette et al., 2021). With few exceptions (UK, Sweden), most of new entries in the long-distance segment take the form of direct on-track competition. The European policy for harmonisation and competition has been implemented by the European Commission since 1991 with three liberalisation packages. Nonetheless, the development of a competitive rail market in Europe has been very slow – much slower than in air and coach markets – and maintained high fragmentation in terms of competition and practices (Beria et al., 2012). The resistance of incumbents against liberalisation and the role of governments supporting this attitude is evident from the available case studies, and in fact the cases of *actual* competition before the 4th package are quite few: Austria, Czechia, Slovakia, Italy, and Sweden, plus some early but failed entries in Germany. The 4th package, finally opening domestic rail markets since December 2019, has instead given the momentum to a new wave of entries, especially in the rich markets of Germany, France, and Spain.

The few earlier mentioned cases (that will be described in more detail in Section 4) have already provided evidence of what happens to markets in competition under European rules, but also showed some differences with respect to other liberalised markets such as air and coach ones. Competition has delivered significant benefits to passengers in terms of improving service quality, encouraging product innovation, and exerting an effect on costs and fares of inefficient companies. The overall consequence has been the generation of new rail demand and general market growth. However, in quantitative terms competition is still in cradle and there is not a clear and unique model for the competitors, like it happened with air low-cost. There have also been some pitfalls, including concerns regarding financial sustainability of competition, the possible impact on public funds, and the overall social welfare effects (Broman & Eliasson, 2019; Cherbonnier et al., 2017; Nash et al., 2019).

Literature involving the study of the effect of competition on prices deserves special mention. Laroche and Lamatkhanova (2021) is probably the first work looking comparatively at rail prices and is an important background for this paper. They deduce that intramodal competition is significantly related to frequency when intermodal competition is related to prices and in most cases, competition is confined to principal routes and does not have a considerable impact on prices because of the duopoly. A second paper of primary importance for our work is Vigren (2017), that empirically explain the mechanisms of price formation under competition. In general, literature is useful also to quantify the real-world effect of competition entries on incumbents' prices, main empirical findings of which are compiled in Table 1.

Table 1
Overview of literature quantifying the effect of market entries on prices.

reference	Observed case	Effect	Period
Vigren (2017)	Stockholm-Gothenburg, entry of MTRx	SJ prices: −12.8%	2015–2016
Tomeš and Jandová (2018)	Vienna-Salzburg, entry of Westbahn	OEBB prices: −20÷25%	2010–2016
Tomeš et al. (2016)	Czechia, entry of RegioJet and Leo Express	Prices: −46%, passengers: +10%	2011–2013
Kvizda and Solnička (2019)	Slovakia, entry and exit of RegioJet	Railway Company of Slovakia (ZSSK): implementation of free tickets for students & seniors	2014–2015
Cascetta & Coppola (2015), Giuricin (2018)	Italy, entry of Italo/NTV	Trenitalia prices: −30÷40%	2012–2015
Beria et al. (2016)	Milan-Ancona, entry of Italo/NTV	Trenitalia cheapest prices: 10–20% Trenitalia 1st class prices: unchanged	2013–2014
Beria et al. (2019)	Italy	Prices of Italo vs. Trenitalia: −10÷20%	2019
Beria et al. (2023)	Milan-Venice, entry of Italo/NTV	Trenitalia prices: −9÷26%	2018
Bergantino (2015)	Rome-Milan	Prices of Trenitalia Vs Italo: +29.92%	2013
	Rome-Venice	Prices of Trenitalia Vs Italo: +30.50%	2013
	Rome-Turin	Prices of Trenitalia Vs Italo: +34.767%	2013

Source: own elaboration on mentioned sources.

Some significant gaps can be however noticed. Price effect estimation typically refers to a single line and a specific entry event. Thus, results can hardly be generalised, as every route and every incumbent/competitor city pair is different. Conversely, a panel data approach is still very rare as requires a lot of observations to control all the relevant variables (socio-economics of the OD pair, supply characteristics, competition, demand characteristics, maturity of competition, etc.). Two other issues must be considered. Literature works typically describe the competition in very simple forms, for example in terms of amount of trains/day per company. But in fact, not all trains are equal on a route, and incumbents tend to have various products with very different pricing schemes. The availability of our database, including the classification of every train category and services in our observations, makes it possible to control this aspect. Lastly, theoretical literature is clear in showing that rail competition often does not focus on prices, but on capacity (Nash et al., 2019; Preston & Wall, 2008). Thus, price-focused studies must not forget that the main battlefield is another one, and that prices are just *a consequence* of supply choices of companies.

Head-on competition in rail has been studied from the theoretical point of view before its actual existence. And such literature, particularly the early one, was not particularly optimistic about the possibility of having, and especially sustaining, long-term competition. In addition, even if competition may exist, its effect in terms of welfare maximisation remains questioned. Johnson and Nash (2012) expect benefits for

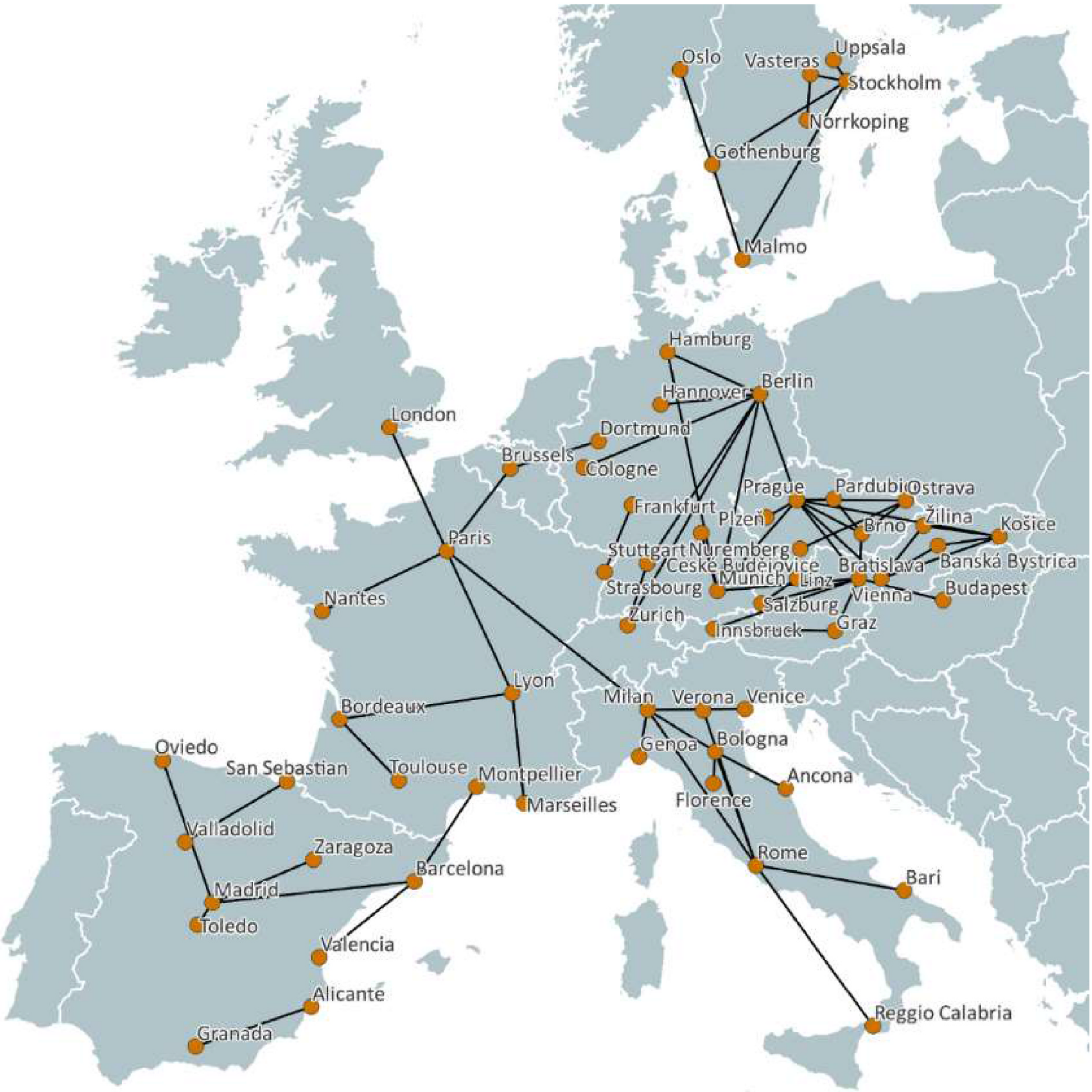

Fig. 1. Map of analysed routes.
Source: own elaboration.

customers both in terms of fares and service frequency, but the profitability of such competition is possible only if the costs of the new entrant were significantly lower. These results suggest that a franchised model would be better than head-on competition. Álvarez-SanJaime, Cantos-Sanchez, Moner-Colonques, and Sempere-Monerris (2015) find that market entries are welfare enhancing only in presence of large traffic induction. Otherwise, if generated traffic is low – typically on thin or already exploited routes – welfare losses can be expected. Moreover, if all players are not welfare-maximising, but profit-maximising, no users benefit can be expected. Two more recent works find intermediate results. Cherbonnier et al. (2017) find that a decrease in fares is not guaranteed under any competition model and that in case of competition "in" the market, benefits in general remain uncertain. Blayac and Bougette (2017), instead, affirm that competition delivers benefits in terms of quality and quantity, but not prices. Recent works look instead more optimistic. Competition, for Nash et al. (2019), potentially reduces fares and increases quality but may nevertheless generate social welfare losses because of negative network effects for the incumbent and its customers. Broman and Eliasson (2019) finally find that if the monopolist is profit-maximising, a duopoly competition would anyway increase aggregate social welfare.

Overall, we may summarise that theoretical literature is indicating that competition is beneficial if the incumbent is behaving as a welfare maximising agent and if it can stimulate significant new demand. In other words, cherry-picking is not beneficial for anyone, while intensive and innovative competition against inefficient incumbents may be extremely positive in terms of welfare.

However, the welfare effect of competition is not telling us about the actual profitability and ultimately about the possibility of competition to deploy and survive. Ivaldi and Vibes (2008) is a significant contribution on that. Through a multimodal model based on game theory, they are capable to demonstrate the unsustainability of a niche operator (Connex, that actually failed) and the profitability of a low-cost intensive train operator, capable of subtracting traffic to low-cost airlines but also to increase the total demand. A further effect is a reduction in fares of 30% for the incumbent.

In the following we will describe the current situation of on track competition in Europe, having in mind what the theoretical literature said in terms of effect on fares, frequency and profitability.

3. Data and methods

The following two sub-chapters describe the data processing necessary to assess the phenomenon of competition changes and the methods for its interpretation.

3.1. Data

Our work relies on a large, complex, and detailed database of supply and fares collected for all modes (plane, train, carpooling and coach) on a seasonal basis. The collection initially considers about 100 city pairs in Europe, monitored for two 14-day periods (Spring and Autumn) during 2019. The fares have been manually crawled through various sources/ operator/reseller websites, 1 and 10 days in advance of the travel date. The current paper includes 69 out of the original 100 city pairs filtered based on the scope and relevance of this research[2]. The original dataset consists of 738,000 observations which will be more than halved[3] after the cleaning procedure described in the following. Fig. 1 maps the 69 routes selected according to possible situations: HS and conventional lines, various distances, with or without PSO trains, with or without air and coach competition, with or without direct competition, international and domestic, geographical coverage, etc. The heterogeneity of these city-pairs allows us to reason on the different forms of competition in the intercity market, in presence of intermodal competition, but also in presence of indirect competition from other rail services, such as PSOs.

More in detail, for each scheduled journey between an origin-destination (OD) pair at pre-defined city stations, the following information have been collected: day of purchase and day of travel, train number and/or train commercial category (when available), station of origin and station of destination, scheduled time of departure and arrival, fare name and level of service (when available), ticket price. Data is enriched with the distance of the OD pair and univocal origin and destination cities. So, for example, all Berlin stations are grouped as "Berlin".

The dataset needed to undergo a thorough semi-automated cleaning process before the analysis. The main steps are:

i. *Recoding of companies*: companies appear with many names when the source is a third party fare finder. For example, RegioJet appears also as "RegioJet a. s." or "Student Agency k.s.". Similarly, "SNCF | Intercités" becomes SNCF.
ii. *Codesharing:* some companies have been merged into one for various reasons. Some, despite having different brands, are actually owned and managed centrally (e.g. Lufthansa and Swiss International Air Lines). Same for some coach groups (e.g. Marino Autolinee and SATAM fall in 2019 under "ibus" brand). We also created mixed companies for international services operated in partnership (e.g. on Prague-Linz ÖBB and České dráhy are mixed into "OBB-CD"). In some cases, we did *not* group companies if it was relevant for the analysis (e.g. Ouigo is not grouped with SNCF because we want to distinguish it from non-low-cost trains). A second level of grouping has been created to correctly calculate the competition level (in this case merging SNCF and Ouigo).
iii. *Perfect and imperfect duplicates removal*: with a very complex procedure we identified and erased the duplicates coming from our companies' code-sharing and renaming (*perfect*, because same departure and arrival), but also from timetables (*imperfect*, because different arrivals or departure). For example, it is a very common case in some countries where trains call at more stations in the same city (e.g. Milano Centrale – Roma Termini and Milano Rogoredo – Roma Termini are typically the same train calling twice in Milan) and so must clearly not be counted twice.
iv. *Service group coding*: with various levels of automation,[4] all trains were classified in one of the following "service groups": *REG* including all regional trains, *HS* including services that use HS rolling stock at least partially on HS lines; *FC* ("fast connections") including the "HS-like" services of countries without a properly said HS network (e.g. ICE in Germany, RailjetExpress in Austria, etc.), *LD* all other long-distance conventional trains.
v. *Night trains coding*: starting from train category (if available) or automatically checking and filtering departure and arrival time, night trains are distinguished to exclude them from some calculations where they could interfere with the analysis.

Table 2
Overview of database consistency after cleaning and reclassification process.

	2019 - Spring		2019 - Fall		
	−10 days	−1 day	−10 days	−1 day	Total observations
Train	**39,987**	**39,906**	**42,839**	**42,253**	**164,985**
Bus	18,009	17,765	23,757	22,490	82,021
Plane	8282	8049	7434	6477	30,242
Taxi	892	702	791	533	2918
Car	5549	20,152	2267	1589	29,557
Total	72,719	86,574	77,088	73,342	**309,723**

Source: own elaboration.

The outcome of this time-consuming procedure has been the halving of the original database, as detailed in Table 2.

To perform the calculations of total supply and HHI (see below), we designated the number of seats to each observations. In order to calculate capacities, different procedures were used for each mode to match the available resources.

In the case of carpooling, the situation is the simplest as a standard passenger car can accommodate 4 passengers. For buses, a simplification was adopted assuming a typical bus with 63 seats. In the case of air transport, the type of aircraft (obtained from Flightradar24.com, 2019) serving the route was tracked for each connection on a given route and the corresponding capacity of the aircraft type (obtained from Seatguru.com, 2019; Aviation-safety.net, 2019) was then assigned.

In the case of trainset capacities, a database of historical development of trainsets in individual railway companies (railfaneurope.net, 2019) was used as a starting point. However, it was subsequently verified according to the information for each mentioned combination of company and route and integrated with missing companies. Carrier websites were also investigated for their fleet and fleet description and subsequently, seat capacities for each train class were verified, adjusted and assigned on a OD pair basis. In case of selected carriers, the number of seats was verified directly from the reservation system available on the web (RegioJet, Czech Railways).

3.2. Measuring competition

Generally, competition can be measured in terms of modal share or through the Herfindahl-Hirschman Index (HHI). HHI is a widely used measure in economics because quantifying, in a compact and

[2] For example, local connections have been excluded

[3] Most of the dropped records are duplicate due to the redundancy of sources we used, but especially to the fact that in some countries – Germany and Austria primarily – trains call at many city stations multiplying the possible ODs.

[4] When train category is available, we referred to that. Same for train number. In the other cases we operated manually, comparing travel with published timetables.

manageable way, market concentration. It is named after economists Orris C. Herfindahl and Albert O. Hirschman, who developed the standard independently in the 1950s. Antitrust regulators frequently use this index to determine whether a merger or acquisition would result in an unacceptable level of market concentration.

The HHI in our research is used to evaluate market competition, as commonly done in previous literature (see for example Motta, 2004). The general definition of HHI is the sum of the squares of all market shares in a market. The resulting value is normalised usually on a range from 0 to 10,000. An HHI of less than 1500 is typically associated to a highly competitive market, whereas an HHI of more than 2500 indicates a concentrated market. Generally, the higher the HHI, the lower is competition and the greater the market power of the firms that operate within it (Department of Justice of United States, 2023). The interpretation of HHI is not always clear (Kelly, 1981); thus, some researchers are discussing the essential pre-conditions of calculating HHI (Roberts, 2014). Overall, it is still commonly used to evaluate market competition or market concentration level and widely accepted in research and practice.

In transport economics, the crucial point is defining the relevant market to calculate HHI. In this point of view, we describe each route connecting two separate cities as one multimodal transport market. For it, different HHIs can be computed, referring to frequency (share of connections/day) or capacity (share of seats/day). In this paper we used capacity because much more representative. We also defined different HHIs according to different grouping of providers (intramodal vs. intermodal competition).

In conclusion, we use the following definitions of rail intramodal and intermodal HHI:

$$HHI_{RAIL} = \sum_{i=1}^{n} share_i^2 = \sum_{i=1}^{n} \frac{seats_i}{\sum seats_n}^2, with\ n = rail\ companies\ operating\ on\ the\ pair$$

$$HHI_{ALL} = \sum_{i=1}^{m} share_i^2 = \sum_{i=1}^{m} \frac{seats_i}{\sum seats_m}^2, with\ m = all\ companies\ operating\ on\ the\ pair$$

4. Overview of relevant transport markets

In this section, we provide a brief review describing country cases of competition. Comparative studies are still few. Apart from Perennes (2017) and Tomeš (2022), that will be mentioned later in regard to supply models, the most relevant one is Laroche and Lamatkhanova (2021) that studies, for the first time, prices in various liberalised markets across Europe.

More common are country-centred studies. In the UK open access competition is limited to routes not served by franchises, offers low-cost, low-fare, low-quality services compared to the franchised intercity operators, but has been effective to stimulate demand (Stead et al., 2019). Temple (2015) focuses on stations and finds that in the ones where Grand Central Express provided novel services in absence of the franchise operator, this led to increased frequency, lower fares to consumers and larger demand and revenues. Similarly, yields on stations with competition increased more slowly than monopolistic ones (+11% vs. +17%). Wheat et al. (2018) concentrates on the cost-side of the open access model, finding a cost advantage (of 34%) additional to lower input costs. These effects offset the lower economies of density with respect to franchised operators, making open-access competition financially viable.

Italy's interesting case generated the largest European non-incumbent rail company, NTV and its brand. *Italo*, reaching a very high level of market share and apparently determining a market equilibrium, with both companies making profits until 2019. For example, in just one year after entry, volumes increased by 82% and passengers by 95% (Desmaris & Croccolo, 2018; NTV, 2019). NTV reached a market share of 24.6% in 2017 considering the relevant market (Beria & Bertolin, 2019), but the figure has likely increased after COVID crisis. Moreover, NTV's entry is sort of an exception when compared to other pre-4th package European entries: it did not enter the market on niche routes and with a low-cost strategy, but rather as a full-scale HS network competitor. The effect on fares is complex to be quantified, as also frequency and capacity are strategically used by competitors (Bergantino et al., 2015). Italo prices are 10–20% less than the national company (Beria et al., 2019). The paper by Beria, Tolentino, Shtele, & Lunkar, 2023 estimates a mid-term effect of 21–26% reduction of Trenitalia prices due to the new entry on the Milan-Venice route, but the effect on early routes prices appeared even larger. The strategic relation between the prices of the two operators is studied by Bergantino et al. (2018), finding a price-leadership of Trenitalia in all competing pairs. The level of access charges in Italy is intermediate among European countries and this has helped the entry in such a rich market differently from what happened in France or Germany. While the conventional services remain around 3–4€/trainkm, the HS services tolls were reduced from 15€/trainkm to 13 and then to less than 8€/trainkm due to a higher traffic density and a regulatory action shifting the focus from the characteristics of the line to those of the service (Rotoli et al., 2018).

The Czech Republic, which shares with Italy the podium of the countries where open access has been deployed more extensively, is characterised by a three-sided competition: the incumbent ČD is challenged by new entrants with diverse business models since 2011 of which the two most important ones being RegioJet since 2011 and LeoExpress since 2013 (Fitzová et al., 2021; Tomeš et al., 2014, 2016). Both started from the main line of the country, the Prague-Ostrava, but later extended their network. The route has ideal conditions for new entrants: high traffic volumes and little intermodal competition because of the absence of a direct highway. They won a combined market share of almost 60% in 2015 (Tomeš et al., 2016). The second important line of the country, Prague-Brno, opened for competition in 2016 (Tomeš & Fitzová, 2019), also reaching Wien and Bratislava. Much later in 2020, newcomers were able also to enter the regional PSO market. The total number of passengers here increased by 67% in 2017 after RegioJet entered in 2016. Differently from other European countries, the complete vertical separation of Czech railways made the entry easier, and this undoubtedly led to higher quality and lower prices. But the Czech competitors faced pricing from the subsidised incumbent that has been investigated for six years by EU antitrust regulators for charging below-cost prices, but finally, this case was dropped due to failure to find sufficient evidence of wrongdoing. Furthermore, competitors struggled with regulatory changes (coexistence of open access and PSO services), which resulted in both being unprofitable (Tomeš & Jandová, 2018). At the same time, also the burden of rail services on public budget rose, both for PSO and discounted fares compensation (Jandová & Paleta, 2019).

Due to strong social ties between Slovakia and Czech Republic and consequently high passenger exchange flows, but without "national" competitors, the Slovak incumbent was challenged by Czech operator RegioJet already at the end of 2014. However, just after the entry the government introduced free travel for children, pensioners, and students, i.e. 42% of the population (IRJ, 2016) on incumbents' PSO trains. These asymmetrical free tickets programme measure did not target InterCity connections and commercial operations, but its effect was an outflow of passengers from commercial services, including new entrant's ones, to the slower subsidised free services (Kvizda & Solnička, 2019; Tomeš & Jandová, 2018). This, of course, jeopardised the sustainability of the entrants.

Sweden is one of the first countries to open and to experience head-on competition (Alexandersson & Rigas, 2013), but for some years the entries were constrained to small niche operators (Fröidh & Nelldal, 2015), such as Blå Tåget. The peculiar regulatory framework of Sweden is unique in Europe and allows open access on any relation, with the sole

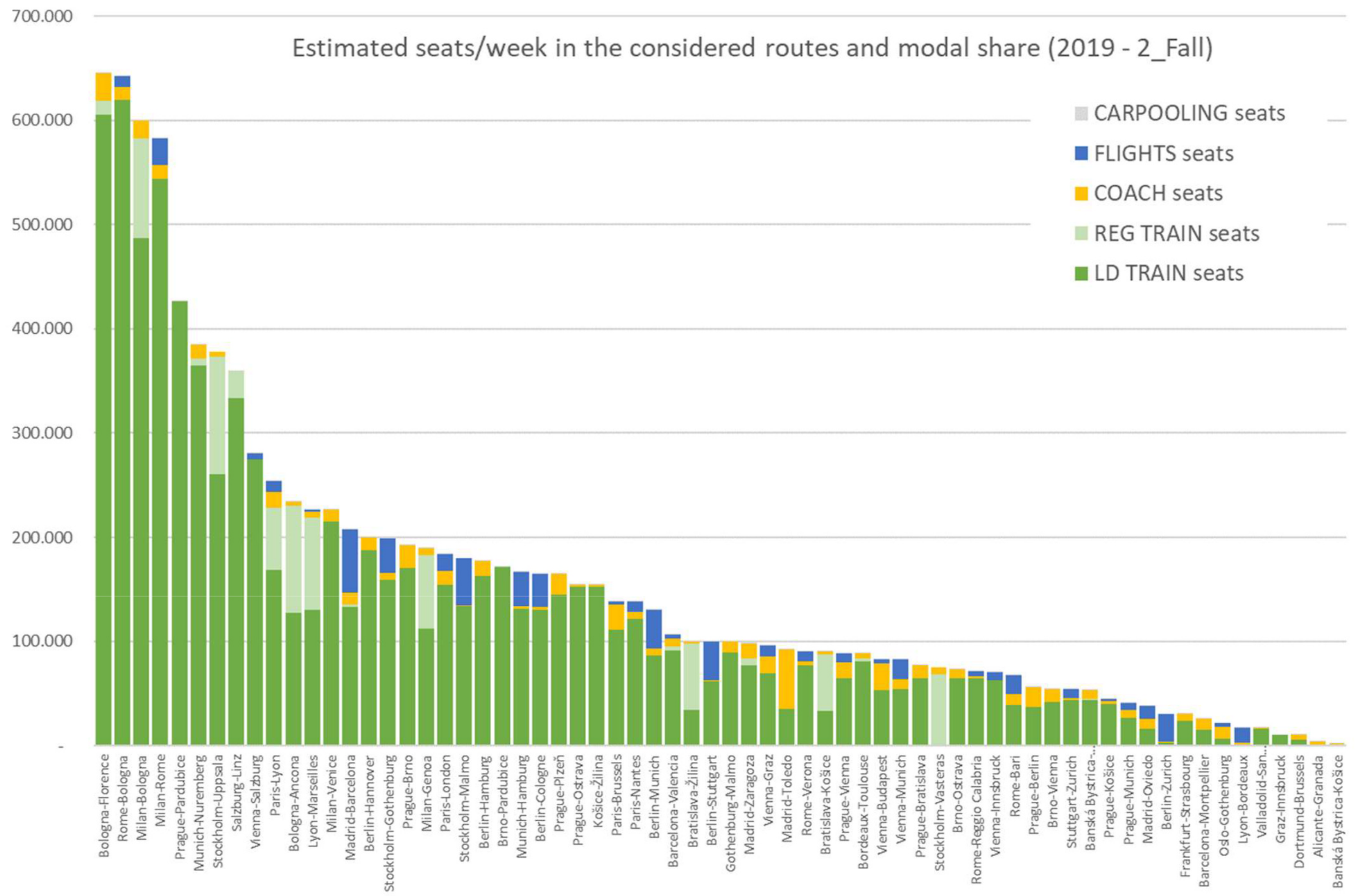

Fig. 2. Bidirectional seats/week per mode, Fall 2019, for the selected routes.
Source: own elaboration based on frequency and on vehicles seats' capacity.

condition of not requiring a compensation. However, also due to the low traffic density, in practice this occurred only on the mainline Stockholm-Gothenburg. The use of fast rolling stock allows to better exploit the characteristics of the line, but at the same time more frequent stops and lower costs kept prices lower and attracted more passengers. There, since 2015 and after having faced and resolved various resistances from the incumbent, operates the private company MTR Express (aka MTRx), reaching a market share of 25% on the line. In May 2021, also Flixtrain started operating on the same line. It is now hard to precisely quantify the market shares of the three players. In terms of trains/day SJ has 69.5%, MTRx 22% and Flixtrain 8.5%, but train compositions of the latter offer more seats and modal share can be – in the future – potentially more. The effect of MTRx entry on incumbent prices have been studied by Vigren (2017), finding a price decrease for SJ of 12.4% one month after the entry of MTRx. After two years MTRx however still suffered losses and the entry of Flixtrain is likely to worsen the situation.

Austria gave way to open access in 2011, but the infrastructure was under the control of the incumbent OEBB and this vertically integrated system poses as a barrier for entrants (Tomeš & Jandová, 2018). Similarly to Sweden, the newcomer Westbahn chose to concentrate on the main and faster line: Vienna-Salzburg. In 2015/2016, 5 years after its entry, Westbahn had a market share of 23% (Presse, 2017) and in 2018, it reached a share of supply almost equal to the OEBB (Oszter & Ács, 2021). In 2022, Westbahn extended its services to Munich.

In Germany, even in the absence of legal regulatory barriers to market entry, open access on-rail competition has been quite limited due to the market power of DB providing more than 99% of long-distance rail services for a decade. Only recently, Flixtrain has started extensive operations of intercity trains, but to date we have very limited evidence in literature (Guihéry, 2020). By 2022 Flixtrain operates six lines in Germany with a low-cost and low-frequency business model, and mostly using 2nd hand rolling stock and.

Competition is less linear in Poland (Król et al., 2018), where from 2009 to 2015, two public companies competed fiercely for a short period: Przewozy Regionalne (PR) and PKP Intercity (PKP IC). During the period of competition, the regions-owned newcomer obtained a significant market share of 33% where present (Król, 2017), but then the national incumbent succeeded (also politically) to wipe it out. Król et al. (2019) discuss the post-Interregio phase, where high number of publicly owned companies try to find some place on market niches providing low-performance and low-cost (25–40% cheaper) services and thus showing that expansion towards new markets can be a possible line of growth.

The last two countries enjoying intercity rail competition are France and Spain. In France, after the 4th package, two newcomers have announced the opening of lines and one – Trenitalia France – has already started operations. The Italian company offers mixed-HS services Milan-Lyon-Paris 2 × day, with the last leg operated 5 × day (vs. 24 × day of SNCF) using the HS line. In Spain competition started in 2022 after an interesting process of "competing for capacity" managed by the network operator ADIF (Montero & Ramos Melero, 2022). Today, both newcomers are active. The French OUIGO, SNCF owned, started earlier supplying 14% of trains between Madrid and Barcelona. More recently Iryo, a joint venture between Trenitalia and AirNostrum, entered on the same route with a frequent 16 × day connection and is ready to open new routes to Sevilla and Cordoba.

All mentioned companies present in the open-access segment do not

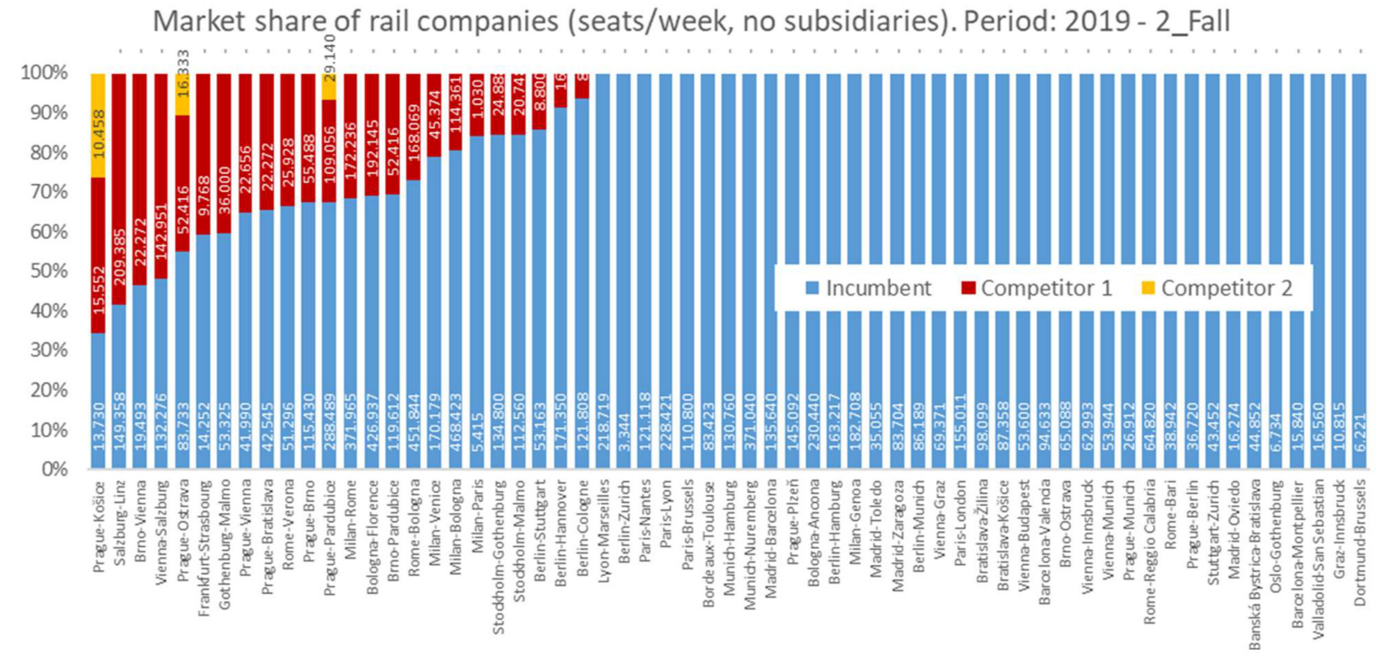

Fig. 3. Intramodal market share of rail companies, in seats/week, Fall 2019. Subsidiaries and codesharing are considered as non-competing and thus computed together (e.g. Ouigo and SNCF or OEBB and DB).
Source: own elaboration.

operate according to one similar business model, like the low-cost one in the air sector. The only similarity is that they all operate thanks to open access rules in a market that is typically largely dominated by an incumbent. Apart from this, single experiences differ significantly in terms of size, level of direct competition, business model, level of service, quality, type of connections and customer base. Literature has already proposed some simple taxonomies of these supply models. Perennes (2017) has assessed the first cases of competition in terms of business model. She describes four models: "greenfield good service quality entrants" (companies challenging incumbent in terms of quality and price on main routes), "low-cost, low-quality operators" (competing on prices), "niche markets" (operators on small routes unserved by the incumbent) and "companies offering otherwise a franchised service" (open access services provided by franchise companies in addition to their contract). According to 2016 situation, just 3 cases belonged to the first type, the two Czech companies and the Italian NTV, while 23 companies belong to the low cost or to the niche models. Interestingly, most of the companies belonging to these groups, disappeared in few years, or remained niche operators basically irrelevant in terms of volumes, while the "greenfield good service" model looks as the only one capable to survive in the long term. Tomeš (2022) provides a simpler classification, that however catches the main difference between companies: "niche", namely small and specialised companies operating in a niche of the market, and "intensive", that not only operate on main markets but also at a large scale, comparable to the one of the incumbents. We will formulate in the final part of the paper an alternative taxonomy to better describe the relationship between supply and the *focus* of competition, which is an element still not considered by literature and that will be the focus of the following empirical analysis.

5. Analysis and results

Given the variety of brands and characteristics of rail services in terms of speed, quality, frequency, etc., we refer hereby only to the simplified classification introduced before (REG, LD, FC, HS), guaranteeing the possibility to compare across different companies and countries.

5.1. Size and structure of the transport markets

Fig. 2 represents the capacity of routes in terms of bidirectional seats per week. We have a rather differentiated situations in terms of modal shares, even if the rail is the dominant mode given the range of distance considered. The pairs most served are – by far – the Italian ones along the backbone HS line (Turin)-Milan-Rome-(Naples). This fact comes from two concurrent reasons. First, the Italian rail geography helps the concentration of supply along that backbone, differently from other "radial" countries such as France or Spain (Albalate & Bel, 2011; Beria et al., 2018; Perl & Goetz, 2015). Second, Italian HS is characterised by intensive competition between the incumbent and Italo/NTV. The competition develops only limitedly in terms of fares (Beria & Bertolin, 2019; Beria et al. 2019; Beria et al., 2023), but harshly in terms of frequency, with up to a HS train every 15′ for each company. A consequence of that is also the use of single-composition trainsets (about 500 seats), instead of double compositions like in France.

Interestingly, among the most crowded rail routes we have also the Prague – Pardubice – Ostrava – Brno and the Vienna – Linz – Salzburg. Like Italy, in both cases the high frequency is due to competition, with respectively three and two competitors pumping trains on the line as to not be marginalised by the other. Other city pairs between comparable or even larger cities than the ones mentioned above, see a much lower rail supply. Paris – Lyon, Madrid – Barcelona, Paris – London or Paris – Brussels had 100 k–170 k HS seats/week during Fall, vs. 500 k of the Italian line, despite the size of the cities, at least comparable to the Italian ones. In terms of connections the difference is even larger in France and to UK, due to the use of higher capacity trainsets (e.g., Eurostar uses up to 900 seats trains, nearly double of Italian 574 seats in ETR 500). This is not contradicting the fact that the Paris – Lyon is considered the most crowded EU line: it is because of the peculiar supply of SNCF, for which most trains from Paris do not call at intermediate cities (or only if there is a stop on the HS line). So, Paris-Lyon is operated with one train and Paris-Marseille with another one, skipping Lyon. In this way, speed is maximised, but frequency not.

Coming to other modes, we notice that just few routes have many flights compared to trains and they are typically in/towards Germany.

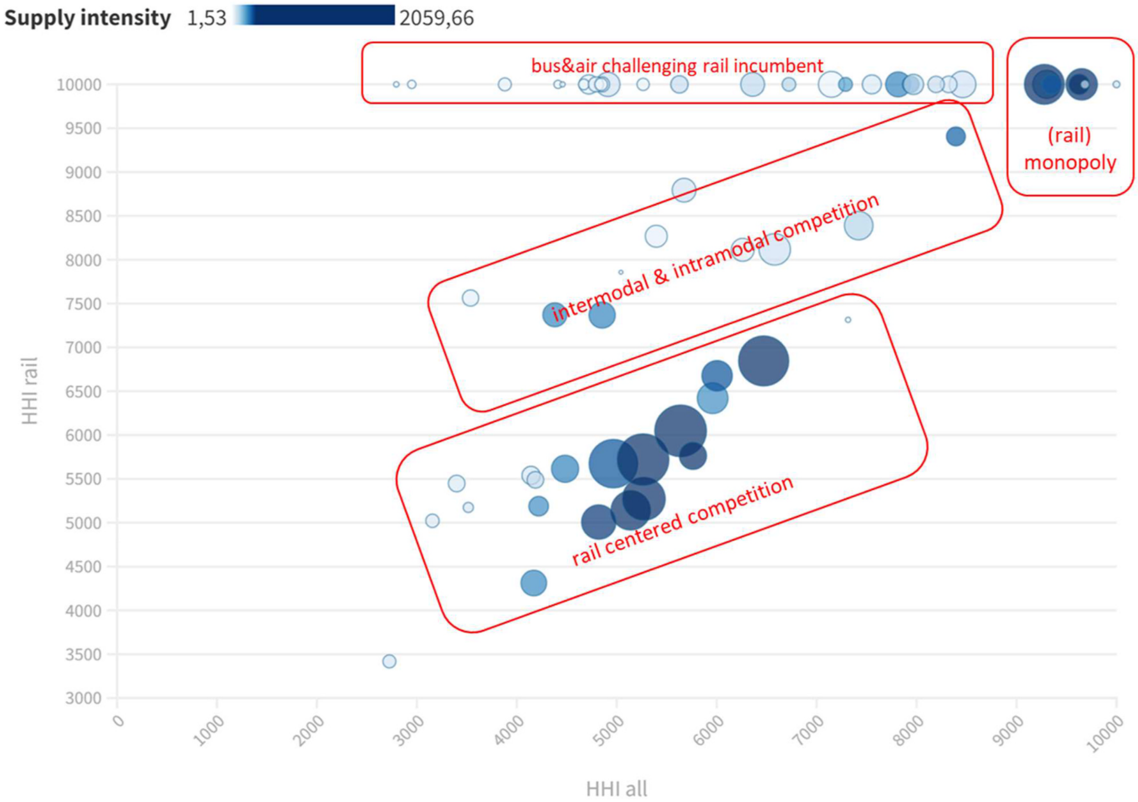

Fig. 4. Classification of intramodal competition (HHI on y-axis), intermodal competition (HHI on x-axis), rail supply (size of dots) and supply intensity in terms of seats per total OD pair population (colour of dots), Fall 2019.
Source: own elaboration.

Elsewhere, relatively few flights remain overlapping HS routes and often this is not for point-to-point traffic but for hub connections. In France, the disappearance of flights to Paris dates to the early HS success. In Spain, flights resist due to aggressive Iberia policy, but they have reduced after the start of competition in 2022.

Evidently, the overall picture of routes ranking changes when considering route frequency instead of seats. The low capacity of coaches makes them the most frequent option in some routes, such as the Vienna-Budapest or the Prague Berlin, with four to five times buses than trains. The same can be observed with planes, with Berlin-Munich twice more frequent by plane and Berlin-Zurich with 174 flights and just 11 trains/week.

5.2. The level of competition

A second theme of interest related to supply is the measure of competition. Our route choices were aimed at considering all possible cases of intramodal and intermodal competition. We have routes with and without rail competition, as well as routes with large or limited intermodal competition, from planes or coaches. Limiting to rail competition, we have, in Fall 2019, 37 pairs in monopoly, 21 in duopoly and 3 involving three competing companies (Fig. 3). Remaining routes are not served by trains (e.g., Alicante – Granada). Overall, we have six routes with incumbent below 60% market share and another eight below 70%. These represent the cases where competition is harsher.[5] In the remaining pairs, competitor is below 30%, belonging to the case of niche products (e.g., Trenitalia's two night trains on the Milan – Paris route, that have disappeared in the meantime).

We compute HHI (Herfindahl-Hirschman Index) based on seats capacity as described in Section 3.2 to classify competition levels and introduce intermodal competition in a better manner. In Fig. 4, the x-axis represents the HHI based on the market share of all companies operating on a route (bus, train, and air companies), while y-axis entails just train companies. Dot size represents the number of seats offered on the city pair and the dot colour represents the intensity of supply computed as the number of seats offered on the pair, divided by the sum of the population of the two cities.

In the chart we can distinguish between rail perfect (or almost perfect) monopolies (top-right), rail monopolists challenged by bus and air companies (top-centre), and various degrees of rail intramodal competition. This group is further split into two (with a quite definite boundary): routes where competition is mostly a rail affair (e.g., Brno – Pardubice: low rail HHI) or routes where intermodal competition is more relevant than intramodal (intermediate rail HHI).

Considering the dot size and colour, the chart evidently shows something already foreseen by theory (Beria, Crozet, & Guihéry, 2022; Nash et al., 2019; Preston & Wall, 2008): rail competition determines an expansion of the supply, both in case of Cournot competition (homogeneous products, like in Italy) or oligopolistic competition with product differentiation (like in Sweden). The higher is the rail competition (y-axis, low HHI) the higher is the intensity of supply (more seats per inhabitant) and the size of the route. Also among rail monopolies we have high supply and intensity cases, but often this includes also regional PSO (e.g. Bologna – Ancona). According to theoretical expectations and empirical observation of previous cases, if the city pairs like Paris-Lyon, Madrid-Barcelona or Paris-London opened to competition, they will experience Cournot competition as their dot will move down (lower HHI) and increase in size and colour, becoming more similar to

[5] There are some caveats. In some cases, the "competition" is not such even if we have two companies. This is the case of OUIGO, that we considered separate from SNCF, or SNCF and Deutsche Bahn on the Frankfurt – Strasbourg where all trains are sold by both companies whoever is the operator.

Table 3
Comparison competitor's prices with respect to incumbent ones, Spring and Fall 2019, selected routes.

connection	country	type	2019 – 1_Spring		2019 – 2_Fall	
			−10	−1	−10	−1
Milan-Rome	IT	HS	−14%	−9%	−16%	−8%
Rome-Verona	IT	HS	−22%	−7%	−20%	−7%
Milan-Venice	IT	FC	−22%	−12%	−19%	−12%
Stockholm-Gothenburg	SE	FC	−27%	−23%	−21%	−17%
Vienna-Salzburg	AT	FC	−28%	−34%	−46%	−38%
Prague-Ostrava	CZ	LD	a	a	−3%	−9%
Prague-Brno	CZ	LD	a	a	−11%	−16%
Berlin-Hannover	DE	LD	−56%	−47%	−54%	−57%
Berlin-Cologne	DE	LD	−68%	−52%	−65%	−59%

[a] Missing data. LeoExpress, the third operator, is present in the Prague – Ostrava route and is pricing more than CD.
Source: own elaboration.

on rails". Recent entries in Spain and France are, again, different stories.

One can adopt three points of view to discuss the price-effect of competition:

i. A direct comparison between peers.
ii. A controlled comparison among heterogeneous panel members.
iii. A time-series analysis to catch the effect on prices of an event such as an entry.

The third approach is the one used by most of previously mentioned literature, that concentrates on single cases of competition. In this work we can exploit the variety of cases to try to find if routes in competition behave differently from monopolistic ones.

The simplest analysis is to compare the prices of competitors on the same market. Table 3 shows that newcomers are systematically cheaper than their incumbent.[6] Flixtrain is the one with the largest difference,

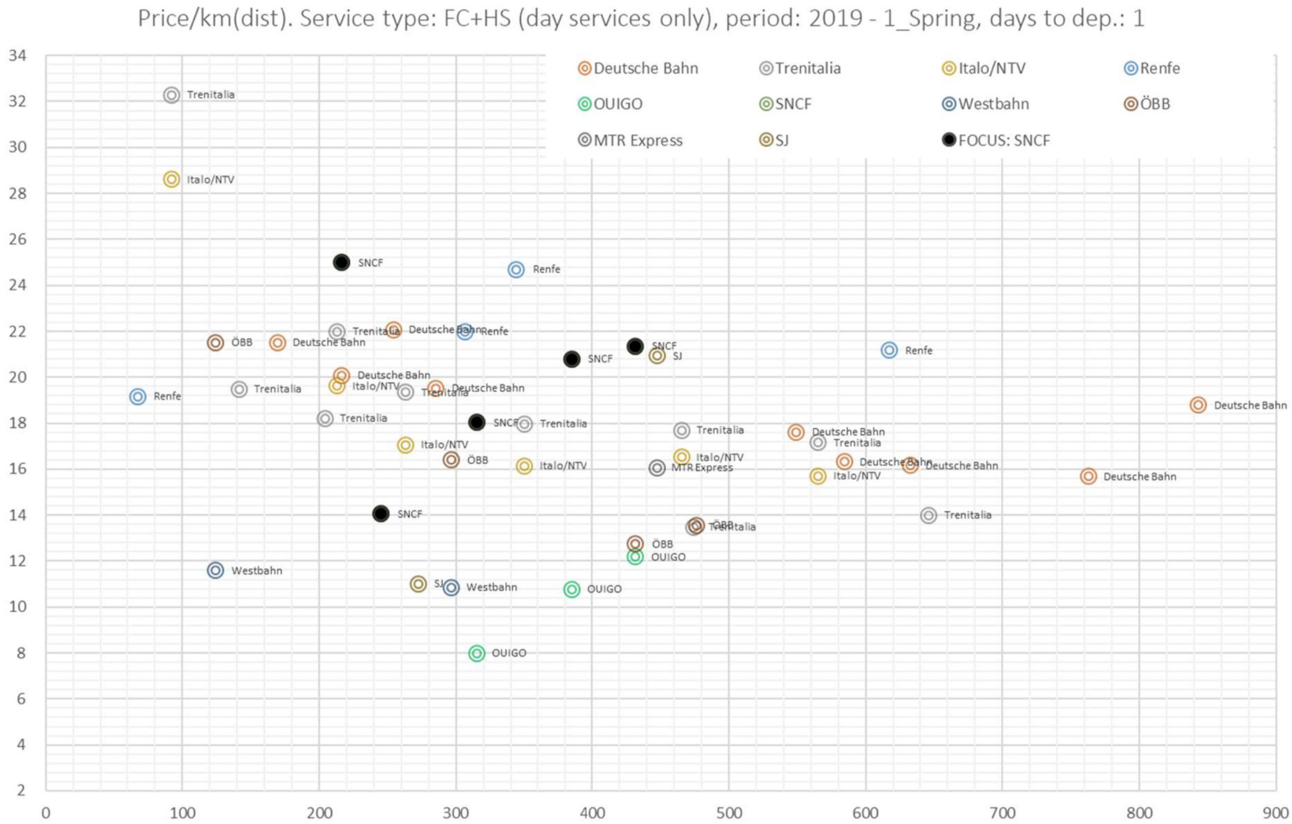

Fig. 5. Dependence of price/km of fast and high-speed services from distance, company, and city pair. Spring 2019, last day price.
Source: own elaboration.

Italian and Central European ones.

5.3. Average prices

We showed that competition in rail primarily expands offer. Nevertheless, competition is expected also to influence prices and literature has found evidence of that, especially in terms of time series.

Studying intramodal competition effects on average prices is complex because of the difficulty to compare across services, countries and time effects. Not only we have few cases of competition, but they are also hardly comparable with each other: the Italian HS competition is different from Swedish and Austrian mainline competition, which differs from the Czech triopoly on intercity services (but with a significant component of mid-distance commuting) and German's Flixtrain "coach because of the aggressive low-cost (but also no-frills) policy adopted to differentiate from Deutsche Bahn. The other cases of intensive competition (Italy, Austria, Sweden, Czechia) see a smaller but significant difference ranging from 10 to 30% less according to the case. Differently from Flixtrain, all of these companies provide a service that is comparable with the incumbent's speed, quality and frequency. The price difference is thus the effect of the lower market power and possibly lower production costs.

Adopting a panel approach is more challenging and gives fewer clear results, because it is dominated by the differences in markets, products, and city pairs. We test the hypothesis that routes in competition have a

[6] With the relevant exception of LeoExpress.

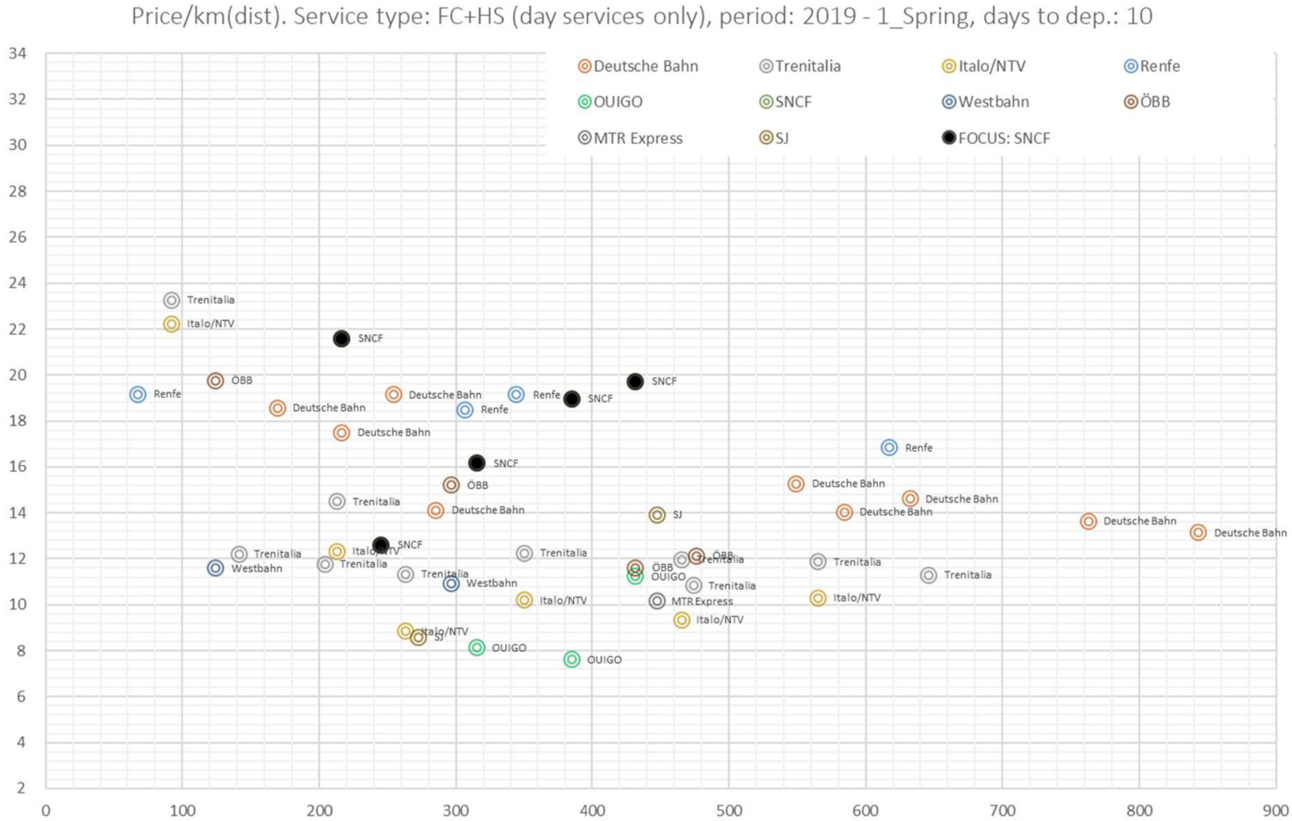

Fig. 6. Dependence of price/km of fast and high-speed services from distance, company, and city pair. Spring 2019, price 10 days in advance.
Source: own elaboration.

lower average price than routes in monopoly, but – as will be clear – other drivers significantly shape the prices.

To appropriately compare prices, a simple price-per-km indicator is not sufficient, because the unit price is highly and unevenly influenced by the distance of the connection. We instead use the average unit prices per route, sub-mode, company to discuss the possible price determinants singularly.

Analysing price distributions like the ones of Figs. 5 and 6, we deduce the following. Both Italian companies Italo/NTV and Trenitalia have a clearly asymptotic distance effect and resulting price functions are also remarkably similar, Italo being 7–25% less expensive than Trenitalia depending on route, season and advance purchase. The effect is less pronounced on conventional pairs, owing to the fact that conventional trains are largely subject to PSO (and long connections are slow and uncompetitive vs. air). MTR Express in Sweden (though we only have one pair) is also less expensive than SJ. The ÖBB, Westbahn, and DB functions in Austria and Germany are not constant, but there is a less pronounced distance effect than in Italy. The German newcomer Flixtrain's conventional services are more than 50% cheaper than DB, but this might include a temporary effect of recent entry.

The French monopolist SNCF does not have a clear price (distance) rule. Price is determined more by the specific city pair than by distance. Its low-cost brand, OUIGO, exhibits similar behaviour but is half the price. RENFE in Spain also shows nearly constant prices (18–19 €cent/km on HS routes; 10–12 on conventional routes). Czech and Slovak companies ČD, Leo Express, RegioJet, and ZSSK distinguish themselves significantly from western competitors in terms of price level - typically ranging between 3 and 6 €cent/km, no differentiation based on anticipated purchase, and no distance dependency (prices almost constant). While one might assume that this is due to the tenacity of traditional fixed pricing of national companies, without yield management, this pricing acts as a "price cap" for dynamic newcomers as well. Coach prices generally follow a similar distance-dependent asymptotic function (Lunkar et al., 2022), are less expensive than trains, but vary greatly between companies and routes. On 200 km routes, for example, prices range between 14 and 1 €cent/km. On longer routes of more than 500 km, between 6 and 1 €cent/km.[7]

However, the key point is that we cannot recognise a clear trend in average prices among EU companies. For example, we cannot simply affirm that monopolies such as DB and RENFE are more expensive than Trenitalia. Moreover, if we consider that in France, the incumbent's owned Ouigo is well below Italian prices on comparable fast services. In fact, other elements influence prices much more than competition, especially in the conventional segment, such as the capability of the incumbent to price more, the speed advantage, quality, frequency, and ultimately also economic geography.

5.4. The role of speed advantage in intermodal competition

When looking at prices across modes, we observe that bus prices are similar to trains just for very short distances (approx. 100 km), while above this threshold trains are systematically more expensive. Flixbus is the only operator present in half of the analysed routes, but its prices can be much cheaper or much more expensive than the rest of the buses depending on the routes. Ryanair is present in just two routes, so to check the effect of low-cost airlines is not possible. Table 4 compares the prices of non-regional trains in the two periods and with the two advanced purchase. Train connections without a competing bus are

[7] Only one company – Eurolines – shows prices up to 30 €cent/km in Spring. This is probably because routes considered are short and domestic, while Eurolines is specialised on very long routes and thus disincentivise travellers on short relations.

Table 4
Price of non-regional trains in function of intermodal competition (advanced purchase, season).

	€cent/km of non-regional trains, −10 days		€cent/km of non-regional trains, −1 day	
	Spring 2019	Fall 2019	Spring 2019	Fall 2019
with bus	11,91	11,34	15,10	13,86
with Flixbus	12,18	10,83	14,93	13,49
without bus	12,97	8,25	13,91	10,00
with plane	13,13	11,57	16,01	14,57
without plane	11,28	10,01	13,45	11,81

Source: own elaboration.

generally cheaper than with bus competition except for early Spring 2019 bookings, which suggests that bus is not systematically lowering train prices, but just case by case. The presence of Flixbus is not changing the pattern: usually trains are slightly cheaper than without Flixbus, but again early Spring 2019 tickets is the exception. Plane comparison is not meaningful because of self-selection: routes with plane are longer, but nevertheless more expensive than the rest of the panel.

The variable that resulted instead very relevant in explaining the prices is the speed – and more specifically the speed advantage – of trains with respect to the competing modes. If we compute the speed advantage of train with respect to bus and plane (>100% means that train is faster), we obtain a very clear effect: the more a train is performing *with respect to competing modes*, the higher is the price that the company can extract from customers. The pattern of Fig. 7, with an almost linear interpolating function for both intermodal competitors, is very similar in other periods and advanced days. This result is even more significant if we consider the price constancy observed in some countries and especially in Czechia and Slovakia. The outlier (45 €cent/km, but reaching 60 one day before departure) is, of course, the Paris – London route. The most competitive train with respect to plane is Paris-Brussels and this makes the route extremely profitable in terms of fare that the passengers are willing to accept (30 €cent/km). For reference, the slightly longer Paris – Lyon stops at 17 €cent/km and the fast Madrid – Barcelona at 15 €cent/km.

5.5. Pricing strategy and dispersion

While the influence of competition on the panel of average prices per km price is barely visible, due to heterogeneity of products and companies' strategies (Section 5.3), a factor requiring more attention is price dispersion.

It is widely acknowledged that often companies operating in the long-distance market extensively use yield management (Beria & Bertolin, 2019; Berto & Gliozzi, 2018; Finger et al., 2016; Guerriero et al., 2022) and price discrimination (Desmaris & Croccolo, 2018; Perennes, 2014; Vigren, 2017) in analogy to what has happened since two decades in air market.

The idea behind is that every customer has a different willingness to pay, and revenues can be maximised by securing the "richer" trips to pay more and then fill the capacity with users progressively paying less (Belobaba, 1987; van Ryzin & Talluri, 2005). One way to do that is through advanced purchase (prices vary – typically increase – with the approaching of the departure day), but many other techniques exist: targeted prices, discounts, classes, flexibility, etc. (Beria & Bertolin, 2019). Whatever is the logic of the yield management, what we observe is that prices differ across routes, days of the week, time, and moment of purchase. The average price of Section 5.3 is the average of all these different combinations. The entity of such differences can however vary

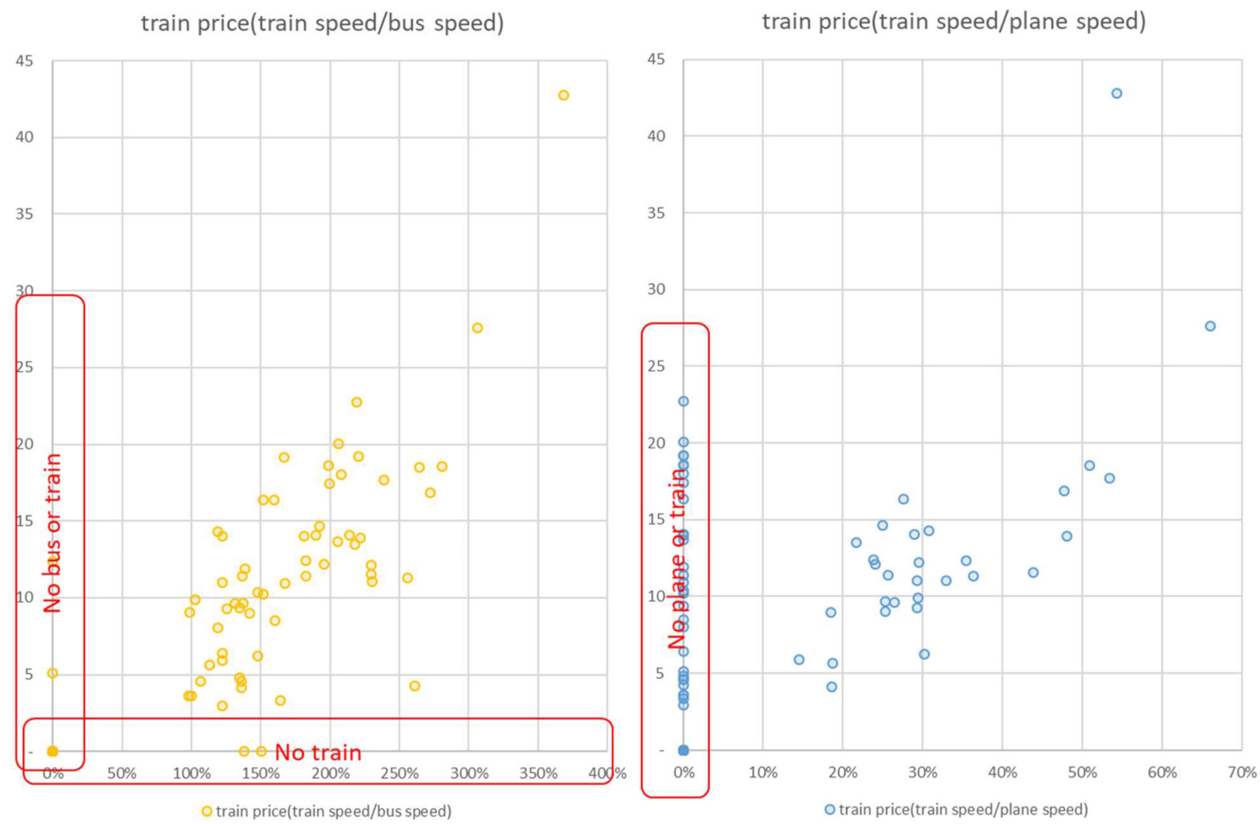

Fig. 7. Price per km of long-distance trains in function of speed advantage on bus (left) and plane (right). Advanced purchase 10 days, period Spring 19. Speed advantage is computed as the speed of train option on the speed of coach and plane options; a percentage of x-axis of more than 100% means that train is faster; if lower than 100% train is slower.
Source: own elaboration.

Fig. 8. Price dispersion on selected comparable HS routes. Frequency of prices observed on each route and company.
Source: own elaboration.

a lot, from cases of nearly fixed prices to cases of extreme variability. Our hypothesis is that the competitive pressure has a role in explaining that.

Looking at Fig. 8, we observe how prices change by time and day of the week for three comparable HS routes: Milan-Rome, Madrid-Barcelona, and Paris-Lyon. The length is not identical, but in all cases, it is the main route of the country, the most performing and connecting the capital with the second urban area of the country. The Italian route is the only one in competition in 2019 and is visibly cheaper 10 days in advance than the Spanish and French ones, except for Ouigo trains that represent the low-cost product of SNCF (lower frequency, high occupancy, secondary stations, no frills). The day before departure the difference is even clearer: SNCF and RENFE still show price dispersion, peak prices are much higher than in Italy and only occasionally RENFE sells tickets cheaper than the Milan-Rome ones. The price of the latter, instead, is not only lower than the two peers, but also fixed: the highest price Italian customers are paying is 16–17 €cent/km, while the French ones reach up to 37 €cent/km. Fig. 9, despite referring to lines of different performance, confirms the finding: companies under competition (WestBahn, Italo/NTV) sell at more fixed prices, generally lower. Monopolists' (Renfe, DB, SJ) early fares are higher but especially more dispersed: they can more easily discriminate their users. These patterns approach the early theoretical expectations that profit and welfare maximising price discrimination under competition is not sustainable (Preston et al., 1999), unless strict conditions are met.

Despite on much lower price levels, also the competitive environment of Central Europe (Fig. 10) sees a substantial invariance of prices, except for Leo Express. Here the effect of competition, however, is also on prices, as visible in the comparison with the more expensive Slovak route. This is probably because – differently from Western national railways – the Czech and Slovak incumbents were not able to exploit their price-setting power before the competition started by adopting aggressive yield management systems (differentiated prices and classes, discounts, distance-dependency, low-cost products, etc.). The effect is that its static pricing, together with an initial low level of fare, acted as a sort of cap on all prices, at benefit of consumers, but heavily threatening the financial sustainability of all companies.

6. Rail companies' strategies under direct competition

Literature has already recognised that there is no single model for rail companies entering in liberalised markets. With respect to previous

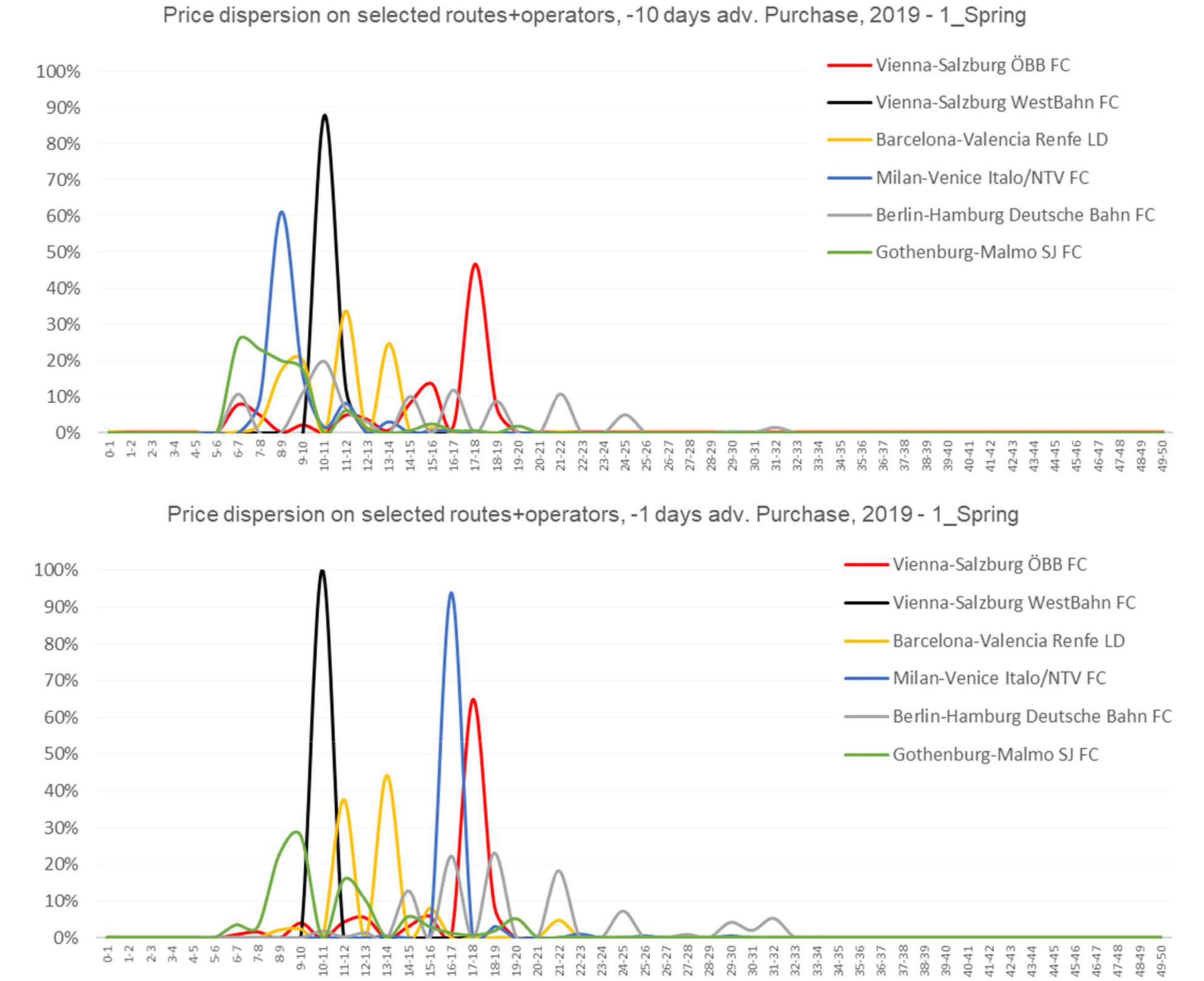

Fig. 9. Price dispersion on selected comparable fast, 300 km long routes. Frequency of prices observed on each route and company.
Source: own elaboration.

attempts, we acknowledge the need of a more detailed classification in addition to the extent of competition. Two dimensions should be considered: one based on the *type of supply of the newcomer* and the other on the *focus of competition* against the incumbent (Fig. 11).

Looking at newcomer's supply, a first segmentation is between *newcomers operating on a single line* and those on a *network*. The distinction is not trivial both looking at real cases and theoretically. Single line operators are typically those focusing on a small niche and prospectively hoping to expand, or operators that operate on the single line of the country that guarantees some traffic to be taken from the incumbent. Network operators instead try to create a network of connections, not necessarily high frequency. A condition for such model is a cost advantage, like for the Czech newcomers, and/or a huge investment capacity, like Italo/NTV in Italy or Iryo in Spain. A second level of segmentation is between *conventional and HS operators*. This distinction exists today, but it is likely that HS operators will progressively expand to conventional network, if successful. The opposite, instead, is not sure, as a low-cost operator will probably remain on the conventional network with cheaper or second-hand rolling stock. The third level is the most important and matches with Tomeš (2022) dichotomy: *intensive* and *niche operators*, that must be read both in terms of frequency and pressure to the incumbent. So, a niche operator will provide few services/day for a small slice of total demand (for example low-cost or luxury travellers, according to cases), while an intensive competition assumes to gain a large market share.

Classifying existing open access operators according to this taxonomy, lets us recognise a limited number of supply strategies. Two companies adopt, to date, a single-line, intensive and HS strategy: Westbahn, MTRx. Trenitalia France also belongs to this group, but it aims at moving to the second group, that of network, intensive and HS companies, together with Italo/NTV, Iryo, and prospectively LeTrain. A single case of network, HS but niche operator can be recognised: Ouigo in Spain, whose market share is structurally limited by the regulation of Spanish network. Single-line, conventional and niche operators existed, but they all failed: HKX, Arenaways and to a certain extent Thello. The only surviving conventional operators all belong to the network group: RegioJet, LeoExpress with intensive competition. An exception is Railcoop in France that aims at building a network but remaining a niche operator for unserved thin routes. These supply strategies will be associated to competition strategies because of the following empirical analysis.

The second dimension – the *focus of competition* – is backed by our

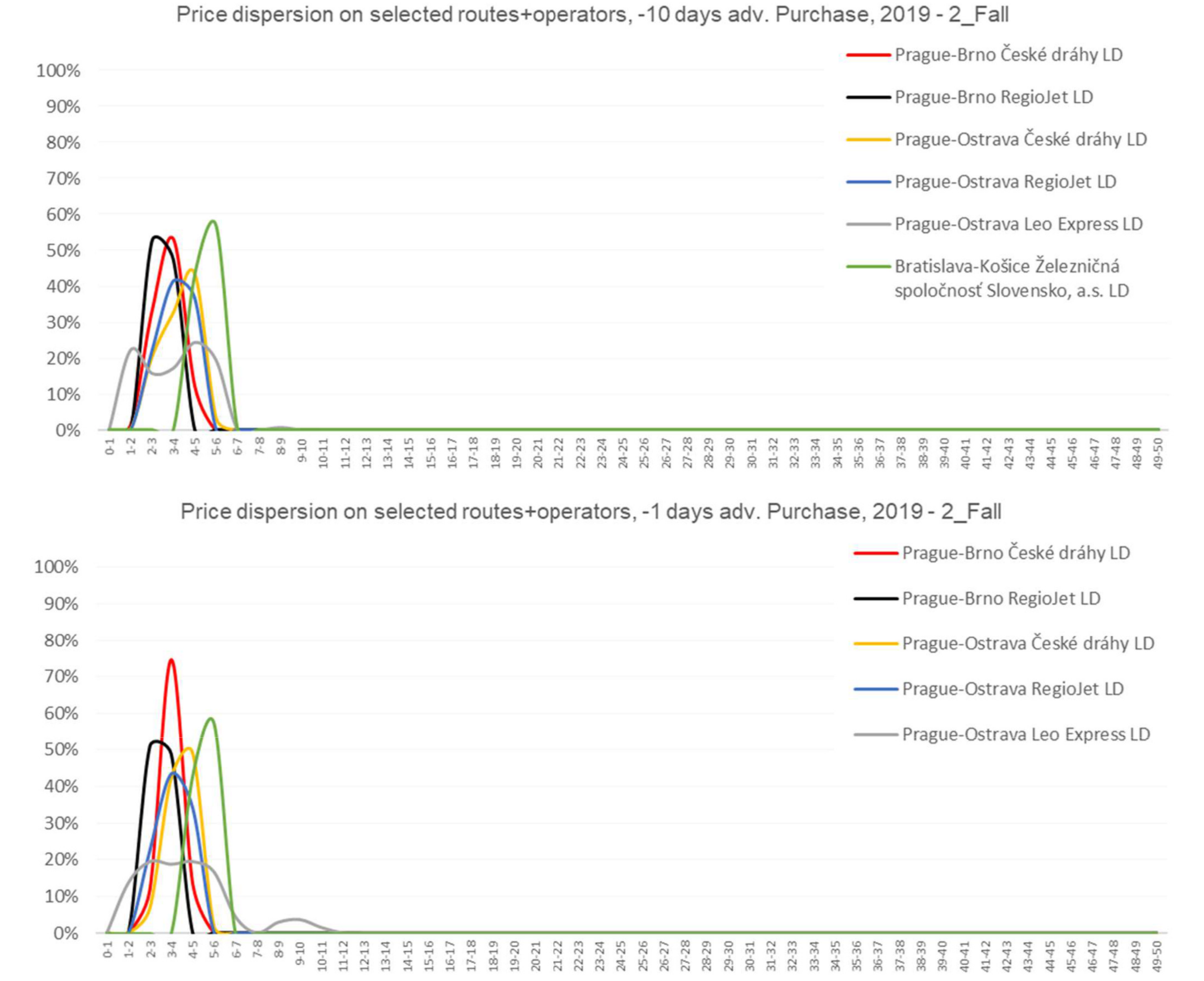

Fig. 10. Price dispersion on Czech and Slovak routes. Frequency of prices observed on each route and company.
Source: own elaboration.

empirical findings. We recognise four types of competition in long-distance open access rail market. They are not mutually exclusive, but one generally prevails, and the others are ancillary.

a. *Price-based competition* (*Bertrand competition*): in case of homogeneous products, Betrand competition may reduce profits or even produce losses, or stimulate efficiency. Price wars for homogeneous products on high-density routes have not been documented to date, except for Czechia (Tomeš et al., 2016), and may typically drive to failures. More commonly found is a variant: newcomer compete on price thanks to the creation of a low-cost product, for example using 2nd hand rolling stock. This is the typical model of niche competitors, with Flixtrain in Germany today as the only network exception.
b. *Quality-based competition*: competition acts on quality, for example providing faster or better trains, or improving ancillary services. This is for example, the case of initial Italo's business model or the Czech companies (Leo Express' newer trains or RegioJet on board services policy) but does not seem to be sustainable out of market niches. Battle for quality benefits users, but may negatively influence prices, reducing potential demand. And, in intercity rail, travel quality alone cannot be attractive without high frequencies.
c. *Frequency-based competition* (*Cournot competition*): when products are comparable (similar routes, trains, and speed), competition push frequencies up, constituting a case of intensive competition (Tomeš, 2022; Bergantino et al., 2015). This is the most common situation today, as also forecasted by theoretical literature (Bergantino & Madio, 2017). Frequency-based competition gives clear benefits to the users, also increasing demand significantly. However, this competition is sustainable only where there is a large potential demand, not on thin routes. In the sample, it is the case of Italy, Sweden, and Austria and of Spain in the future, but also of Czech competitors. In general, frequency-based competition rises total costs and thus prices may not fall (Cherbonnier et al., 2017) or fall only because of excessive capacity (Beria, Crozet, & Guihéry, 2022). A battle for frequency and homogeneous products may drive to an empty core problem (Button, 1996, 2002), bringing instability in the market.
d. *Network/product-based competition*: the competitors may innovate the network, for example by providing previously unserved pairs and thus creating new markets. British open access operators naturally belong to this group. RegioJet out of Czechia is also doing that, as well as (limitedly) Italo in southern Italy. But the most interesting

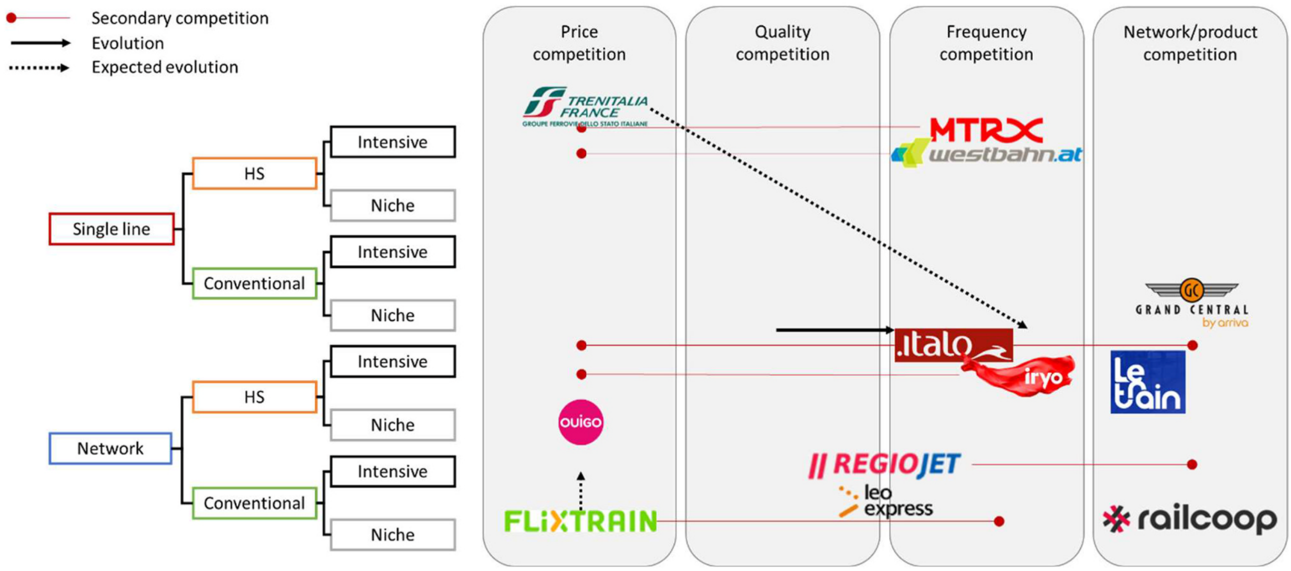

Fig. 11. Schematisation of rail competition models.
Source: own elaboration.

case of network innovation may come from the two expected French newcomers: RailCoop and LeTren, both focusing on unserved SNCF routes. Battle for network is generally beneficial, because creates genuinely new demand, but may have conflicts with particularly integrated networks.

If we observe both dimensions (supply and competition focus) together, we notice (Fig. 11) that single-line intensive competition is always frequency-centred and is adopted by just two companies. Their existence is based on the fact that potential demand unexploited was large and they can cherry-pick it thanks to lower marginal costs. Trenitalia in France started competing on price, but it is already clear from their business plan that they aim to intensive frequency competition on a larger network. The bulk of European competitors is clearly placed: frequency (and secondarily quality) competition on a network, either HS or conventional. Two exceptions are still evolving: the low-cost niche model of Ouigo and Flixtrain (that however already passed from niche to intensive competition on some routes), and the two French expected experiments based on network innovations. Interestingly, failures of the past all belong to the niche and conventional lines group. Having adopted different competition models (price: HKX and Arenaways; quality: Arenaways; network innovation: Thello) did not change their doom.

It is also interesting to comment on the behaviour of monopolists to exploit favourable market conditions. The average prices of monopolies are not necessarily higher (but sometimes yes). This is true not only for Central Europe but also elsewhere. For example, DB has similar prices than its peers, not to mention discounts. However, monopolists typically reduce the quality, both onboard (Czechia) and in terms of frequencies and travel time (Spain, Germany). Thirdly, monopolists focus on core routes and abandon of lower-yield ones (e.g. east-west connections in France).

Finally, monopolies tend to be hypertrophic, growing to occupy all possible markets and prevent the entrance of significant competitors. All services (long-distance, regional, etc.) are tightly integrated in terms of network, pricing system, timetabling, use of capacity (Germany, Austria). Moreover, low-cost brands mimicking competition are created to grab all users on occupied markets, including from coach (France). Loyalty programmes are also used strategically, such as discount cards or schemes (Germany, Austria, Slovakia, Czechia). Fifthly, monopolists reduce seats capacity, not only to optimise costs, but also to exclude passengers from the market pushing prices up (France). Finally, they heavily discriminate users with extreme dynamic pricing, increasing revenues.

7. Conclusion

In our paper, we assessed pieces of evidence on supply and price determinants coming from 69 European city-pairs. We identified the relationship between offer and competition level, finding that the higher is the intramodal competition, the more frequent are the services, but using smaller trainsets than demand would justify. From another perspective, monopolists do not need to overextend frequency (which is costly) and, if demand is large, rather increase train capacity or exclude potential users with high prices.

Average prices are influenced in a double way: incumbents reduce prices with respect to pre-competition, but nevertheless, newcomers remain generally cheaper. From a comparative EU perspective, however, our panel is not demonstrating that competition routes are cheaper than monopoly routes because the prices are largely determined by other factors (capacity, subsidies, socio-economic factors, etc.) and markets are not mature. An effect clearly visible on average prices in all of Europe is linked to the speed advantage of train vs. other modes: the faster the train is with respect to concurrent coach and plane, the higher the prices because the willingness to pay of users is exploited, also in competition.

We instead found an effect on prices related to the distribution: the more a route is competitive, the lesser companies discriminate prices, a practice instead widely used by "smart" monopolists. So, the benefit of competition is more for peak users that are not exploited excessively. Heavily subsidised monopolists failing to adopt yield management systems early remain trapped in a poor price scheme, capping the prices of the entire market. In such cases, competition cannot compress further prices and focus on quality and frequency.

It is hard to foresee the evolutions of such a complex and varied market. But some trends can be tentatively proposed. Price wars will not be common (like it was in air transport), rather frequency-wars on core routes, a form of Cournot competition. Frequency wars may jeopardise the financial sustainability in case of crises or predatory behaviours. Moreover, frequency wars – whose Italy is the most prominent case – saturate capacity, prevent the existence of other services, degrade the network performance. In this sense the Spanish approach "network manager-driven" looks much wiser. This suggests that regulators and network managers should play a bigger role than just letting anybody add trains, also for competitors' long-term financial health. When demand is huge, the simplest way is to stimulate double compositions, common in Germany and France, but not in Italy. With frequency wars, prices will not fall too much, because cost is incurred by increasing supply on saturated lines. In any case, coaches and PSO trains can guarantee low-cost customers. There is probably space for low-cost trains (Flixtrain, Ouigo), but on very dense routes only. Niche cherry-picking, instead, does not work, while niche services may exist if they innovate the network (which would be extremely beneficial, but not often seen as a strategy by newcomers until now).

Clearly this work is not free from limits and will be improved in the future. As it is, the database is a static picture of 2019 and can be usefully reproduced for the post-COVID world. In general, when time series will be sufficiently long, the described phenomena will be analysed dynamically, too. Finally, the natural and probably the most potential use of the database is as a panel data for an econometric analysis. In this sense, the current paper may constitute the necessary preparatory work for a well-grounded statistical approach.

Author statement

BERIA Paolo: Conceptualization, Methodology, Verification, Formal Analysis, Writing – Original draft, Writing - Review & Editing, Supervision, Project Administration.

LUNKAR Vardhman: Data curation, Investigation, Validation, Verification, Formal analysis, Writing - Review & Editing, Visualisation.

TOLENTINO Samuel: Methodology, Data curation, Investigation, Software, Validation.

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Declaration of competing interest

Paolo Beria, Vardhman Lunkar and Samuel Tolentino declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Albalate, D., & Bel, G. (2011). Cuando la economía no importa: Auge y esplendor de la alta velocidad en españa. *Revista de Economia Aplicada, 19*(55), 171–190.

Alexandersson, G., & Rigas, K. (2013). Rail liberalisation in Sweden. Policy development in a European context. *Research in Transportation Business & Management, 6*, 88–98.

Álvarez-SanJaime, Ó., Cantos-Sanchez, P., Moner-Colonques, R., & Sempere-Monerris, J. J. (2015). A model of internal and external competition in a High Speed Rail line. *Economics of Transportation, 4*(3), 178–187.

Aviation-safety.net. (2019). The flight safety Foundation's aviation safety network. Retrieved July, 2019 from: https://aviation-safety.net/.

Belobaba, P. P. (1987). Survey paper—airline yield management an overview of seat inventory control. *Transportation Science, 21*(2), 63–73.

Bergantino, A. S. (2015). Incumbents and new entrants. In *Rail economics, policy and regulation in Europe*. Edward Elgar Publishing.

Bergantino, A. S., Capozza, C., & Capurso, M. (2015). The impact of open access on intra- and inter-modal rail competition. A national level analysis in Italy. *Transport Policy, 39*, 77–86.

Bergantino, A. S., Capozza, C., & Capurso, M. (2018). Pricing strategies: Who leads and who follows in the air and rail passenger markets in Italy. *Applied Economics*, 4937–4953.

Bergantino, A. S., & Madio, L. (2017). High-speed rail, inter-modal substitution and willingness-to-pay. A stated preference analysis for the 'Bari-Rome' (November 23, 2017). Working Papers SIET 2017, Available at: SSRN: https://ssrn.com/abstract=3091537.

Beria, P., & Bertolin, A. (2019). Evolving Long-distance passenger services. Market concentration, fares and specialisation patterns in Italy. *Research in Transportation Economics*, (74), 77–92.

Beria, P., Crozet, Y., & Guihéry, L. (2022). Transport ferroviaire de passagers: La concurrence "sur le marché" s' installe en Europe. *TRANSPORTS, Infrastructures & Mobilités*, (533), 37–46.

Beria, P., Grimaldi, R., Albalate, D., & Bel, G. (2018). Delusions of success: Costs and demand of high-speed rail in Italy and Spain. *Transport Policy, 68*, 63–79.

Beria, P., Quinet, E., de Rus, G., & Schulz, C. (2012). A comparison of rail liberalisation levels across four European countries. *Research in Transportation Economics, 36*, 110–120.

Beria, P., Redondi, R., & Malighetti, P. (2016). The effect of open access competition on average rail prices. The case of Milan–Ancona. *Journal of Rail Transport Planning & Management, 6*(3), 271–283.

Beria, P., Tolentino, S., Bertolin, A., & Filippini, G. (2019). Long-distance rail prices in a competitive market. Evidence from head-on competition in Italy. *Journal of Rail Transport Planning & Management, 12*, Article 100144.

Beria, P., Tolentino, S., Shtele, E., & Lunkar, V. (2023). A difference-in-difference approach to estimate the price effect of market entry in high-speed rail. Competition and Regulation in Network. *Industries, 23*(3), 183–213, 17835917221088770.

Berto, A., & Gliozzi, S. (2018). Unconstraining the passenger demand for rail yield management at Trenitalia. *Electronic Notes in Discrete Mathematics, 69*, 269–276.

Blayac, T., & Bougette, P. (2017). Should I go by bus? The liberalisation of the long-distance bus industry in France. *Transport Policy, 56*, 50–62.

Bougette, P., Gautier, A., & Marty, F. (2021). Which access to which assets for an effective liberalisation of the rail sector. *Competition and Regulation in Network Industries, 22*(2), 87–110.

Broman, E., & Eliasson, J. (2019). Welfare effects of open access competition on railway markets. *Transportation Research Part A: Policy and Practice, 129*, 72–91.

Button, K. (1996). Liberalising European aviation: Is there an empty core problem? *Journal of Transport Economics and Policy*, 275–291.

Button, K. (2002). Empty cores in airline markets. In *5th hamburg aviation conference*. Hamburg.

Cascetta, E., & Coppola, P. (2015). New high-speed rail lines and market competition: Short-term effects on services and demand in Italy. *Transportation Research Record, 2475*(1), 8–15.

Cherbonnier, F., Ivaldi, M., Muller-Vibes, C., & Van Der Straeten, K. (2017). Competition for versus in the market of long-distance passenger rail services. *Review of Network Economics, 16*(2), 203–238.

Department of Justice of United States. (2023). Herfindahl-hirschman index. Retrieved February 20, 2023 from: https://www.justice.gov/atr/herfindahl-hirschman-index.

Desmaris, C., & Croccolo, F. (2018). The HSR competition in Italy: How are the regulatory design and practices concerned? *Research in Transportation Economics, 69*, 290–299.

Finger, M. (2014). Governance of competition and performance in European railways: An analysis of five cases. *Utilities Policy, 31*, 278–288.

Finger, M., Kupfer, D., & Montero-Pascual, J. J. (2016). *Competition in the railway passenger market*. Technical Report. EUI: Florence School of Regulation.

Fitzová, H., Kališ, R., Pařil, V., & Kasa, M. (2021). *Competition in long distance transport: Impacts on prices, frequencies, and demand in the Czech Republic*. Research in Transportation Business & Management, Article 100655.

Flightradar24.com. (2019). Global flight tracking service. Retrieved July, 2019 from: https://www.flightradar24.com/51.5,-0.12/6.

Fröidh, O., & Nelldal, B. L. (2015). The impact of market opening on the supply of interregional train services. *Journal of Transport Geography, 46*, 189–200.

Giuricin, A. (2018). Ownership change heralds expansion at italo-NTV (article at railway Gazette international). *Railway Gazette*, 1–4.

Guerriero, F., Rocchi, S., Iazzolino, G., & Manfredi, W. (2022). An empirical assessment of pricing efficiency across the European rail market. *Research in Transportation Business & Management*, Article 100782.

Guihéry, L. (2020). Autocars interurbains en allemagne: Pour FlixBus, le temps des interrogations. *TI&M, Transports, Infrastructures & Mobilité*, (521), 33.

IRJ. (2016). ZSSK revives Bratislava – Kosice intercity services [03–04–2017]. https://www.railjournal.com/index.php/main-line/zssk-to-revive-bratislava-kosice-inter-city-services.html. International Railway Journal.

Ivaldi, M., & Vibes, C. (2008). Price competition in the intercity passenger transport market: A simulation model. *Journal of Transport Economics and Policy, 42*(2), 225–254.

Jandová, M., & Paleta, T. (2019). Impact of on-track competition on public finances–The case of the Czech Republic. *Journal of Rail Transport Planning & Management, 12*, Article 100145.

Johnson, D., & Nash, C. (2012). Competition and the provision of rail passenger services: A simulation exercise. *Journal of Rail Transport Planning & Management, 2*(1–2), 14–22.
Kelly, W. A. (1981). A generalised interpretation of the Herfindahl index. *Southern Economic Journal*, 50–57.
Król, M. (2017). Open access competition in the long-distance passenger rail services in Poland. *Yearbook of Antitrust and Regulatory Studies (YARS), 10*(16), 155–166.
Król, M., Taczanowski, J., Jarecki, S., & Kołoś, A. (2019). Publicly-owned operators can also challenge incumbents. New cases of open-access passenger rail competition in Poland. *Journal of Rail Transport Planning & Management, 12*, Article 100150.
Król, M., Taczanowski, J., & Kołoś, A. (2018). The rise and fall of Interregio. Extensive open-access passenger rail competition in Poland. *Research in Transportation Economics, 72*, 37–48.
Kvizda, M., & Solnička, J. (2019). Open access passenger rail competition in Slovakia–experience from the Bratislava–Košice line. *Journal of Rail Transport Planning & Management, 12*, Article 100143.
Laroche, F., & Lamatkhanova, A. (2021). Effects of open access competition on prices and frequencies on the interurban railway market: Evidence from Europe. *Research in Transportation Business & Management*, Article 100705.
Lunkar, V., Beria, P., & Tolentino, S. (2022). Out of the spotlight: Four years of Italian coach market prices. *Research in Transportation Business & Management, 43*, Article 100798.
Montero, J. J., & Ramos Melero, R. (2022). Competitive tendering for rail track capacity: The liberalisation of railway services in Spain. *Competition and Regulation in Network Industries, 23*(1), 43–59.
Montero, J. J., Ramos, R., & Giuricin, A. (2016). Open with care: The duopoly model for the transition to competition in long-distance passenger railway transportation. *Competition and Regulation in Network Industries, 17*(3–4), 241–259.
Motta, M. (2004). *Competition policy: Theory and practice*. Cambridge university press.
Nash, C., Smith, A., Crozet, Y., Link, H., & Nilsson, J. E. (2019). How to liberalise rail passenger services? Lessons from european experience. *Transport Policy, 79*, 11–20.
NTV. (2019). *Italo - Nuovo Trasporto Viaggiatori. Company profile*. November 2019. NTV.
Oszter, V., & Ács, B. (2021). When market opening reverses – comparative analysis of public transport policy of multiple Central and Eastern European countries. In *Presented at: European Transport Conference 2021*.
Perennes, P. (2014). *Intermodal competition: Studying the pricing strategy of the French rail monopoly*, 2014. Transport Research Arena.
Perennes, P. (2017). Open access for rail passenger services in Europe: Lesson learnt from forerunner countries. *Transportation Research Procedia, 25*, 358–367.
Perl, A. D., & Goetz, A. R. (2015). Corridors, hybrids and networks: Three global development strategies for high speed rail. *Journal of Transport Geography, 42*, 134–144.
Presse, D. (2017). Westbahn fahrt in richtung Gewinn. Die Presse, 19–03–2018. Available at: https://diepresse.com/home/wirtschaft/economist/5221076/Westbahn-faehrt-in-Richtung-Gewinn.
Preston, J., & Wall, G. (2008). The ex-ante and ex-post economic and social impacts of the introduction of high-speed trains in South East England. *Planning Practice and Research, 23*(3), 403–422.
Preston, J., Whelan, G., & Wardman, M. (1999). An analysis of the potential for on-track competition in the British passenger rail industry. *J. Transport Econ. Pol., 33*(1), 77–94.
Railfaneurope. (2019). Database on train types used by relevant railway carriers. Retrieved July, 2019 from: http://www.railfaneurope.net/list/germany_db_fv.html.
Roberts, T. (2014). When bigger is better: A critique of the Herfindahl-Hirschman index's use to evaluate mergers in network industries. *Pace Law Review, 34*, 894.
Rotoli, F., Valeri, E., Ricci, S., Rizzetto, L., & Malavasi, G. (2018). An analysis of the railway access charges regime in the Italian context. *Transport Policy, 64*, 20–28.
van Ryzin, G. J., & Talluri, K. T. (2005). An introduction to revenue management. In *Emerging theory, methods, and applications* (pp. 142–194). Informs.
Seatguru.com. (2019). Database on aircraft types. Retrieved July, 2019 from: https://seatguru.com/.
Stead, A. D., Wheat, P., Smith, A. S., & Ojeda-Cabral, M. (2019). Competition for and in the passenger rail market: Comparing open access versus franchised train operators' costs and reliability in Britain. *Journal of Rail Transport Planning & Management, 12*, Article 100142.
Temple, S. (2015). Open access long distance passenger rail services in the United Kingdom: The grand central experience. *Transportation Research Procedia, 8*, 114–124.
Tomeš, Z. (2022). Regulatory approaches to rail competitive entries. *Competition and Regulation in Network Industries.* https://doi.org/10.1177/17835917221106071
Tomeš, Z., & Fitzová, H. (2019). Does the incumbent have an advantage in open access passenger rail competition? A case study on the Prague–Brno line. *Journal of Rail Transport Planning & Management, 12*, Article 100140.
Tomeš, Z., & Jandová, M. (2018). Open access passenger rail services in Central Europe. *Research in Transportation Economics*, (72), 74–81.
Tomeš, Z., Kvizda, M., Jandová, M., & Rederer, V. (2016). Open access passenger rail competition in the Czech Republic. *Transport Policy, 47*, 203–211.
Tomeš, Z., Kvizda, M., Nigrin, T., & Seidenglanz, D. (2014). Competition in the railway passenger market in the Czech Republic. *Research in Transportation Economics, 48*, 270–276.
Vigren, A. (2017). Competition in Swedish passenger railway: Entry in an open access market and its effect on prices. *Economics of transportation, 11*, 49–59.
Wheat, P., Smith, A. S., & Rasmussen, T. (2018). Can competition for and in the market co-exist in terms of delivering cost efficient services? Evidence from open access train operators and their franchised counterparts in Britain. *Transportation Research Part A: Policy and Practice, 113*, 114–124.