ERASMUS UNIVERITY ROTTERDAM

Erasmus School of Economics

Bachelor Thesis [programme Economics and Business Economics]

The effect of open access competition in the long distance passenger rail market on rail ticket prices

Name student: Valentijn Vlek

Student ID number: 518833

Supervisor: Floris de Haan MSc

Second assessor: Susan Vermeulen MSc

Date final version: 20-07-2021

Abstract

In this thesis we study the effect of open access competition in the long distance passenger rail market on rail ticket prices. Hereby we focus on intramodal competition. For our comprehensive analysis we obtained data from all EU long distance passenger rail markets with large scale open access competition. These countries are Austria, CZ, Italy, Spain and Sweden. We found that the results on the effect of open access competition on ticket prices differs among countries. Our results show that the ticket price of the entrant operators is lower compared to the ticket price of the incumbent operator. Our results also show that ticket prices on routes with open access competition are lower compared to routes without open access competition. Moreover, we show that the ticket price decreases diminishing when booked more days ahead of departure.

Table of contents

1. Introduction

In the past decades competition in the long distance passenger rail market has increased, but only since the second decade of the 21th century open access competition arose as a result of EU legislation regarding liberalisation of the railway market. The purpose of the introduction of open access competition was to attract new operators in the EU railway market, that directly compete with state-owned incumbent operators. This should have resulted in gains in both intermodal and intramodal competition. For instance, a modal shift from airlines to sustainable travel by high speed rail services, lower rail ticket prices, and an improved level of service in terms of more frequent trains and better onboard services.

Existing research provides insight into examples of these purposes of open access competition. Regarding to the modal shift from airline to train some research has been done. For instance, according to research in France high speed rail services can be very attractive instead of airline services (Delaplace & Dobruszkes, 2015). In addition, this claim is supported by research on the Paris – London route (Behrens & Pels, 2012). According to lower rail ticket prices and improved services some research has been performed as well. In Italy open access competition resulted in strategic pricing, reduced fares and improved services among competing operators (Bergantino et al., 2015). This is confirmed by research to the Milan – Ancona branch (Beria et al., 2016). Other research in Sweden supports these outcomes and confirms lower ticket prices and increased supply of trains (Vigren, 2017). Research in CZ found comparable results with lower fares, standardisation and improvement of onboard services and more daily connections (Tomes et al., 2016).

However, the existing research only focuses on one specific country. In general, from this research we may observe that the introduction of open access competition leads to lower rail ticket prices. Unfortunately, it is hard to say from these examples on country level what the effect of open access competition on railway fares is as this effect differs between the countries previously studied. The introduction of open access competition and the entry of new operators in the long distance passenger rail market deserves to be studied on aggregate level. At the time of writing there exists no previous research on overall effects of all countries of open access competition. In times where liberalisation of the passenger railway market and the introduction of open access competition in het EU is highly controversial, research on these overall effects of all countries is necessary to make good policy interventions on the future of the EU passenger railway market. This paper provides insights into the overall effect of open access competition on ticket prices in the passenger rail market and does not focus on one specific country. We use data from all EU countries where carriers operate under open access competition on large scale. These countries are Austria, Czech Republic, Italy, Spain and Sweden.

The aim of this paper is to address the effect on rail ticket prices of open access competition in the long distance passenger rail market. We study intramodal competition, e.g. direct competition among train operators on the same tracks, on the same route, for the same passengers and at the same time. Thus, we do not focus on intermodal competition, e.g. competition between train and airlines or busses. Also, in our study on intramodal competition we only focus on long distance train services, e.g. high speed rail services or equivalent fast trains. This implies that regional trains are out of the scope of this research. Our main research question is stated as follows:

What is the effect of open access competition in the long distance passenger rail market on rail ticket prices?

To answer this question we answer several sub questions. This questions are as follows:

What pricing behaviour of incumbent operators and entrant operators do we observe under open access competition on country and aggregate level?

Is there a difference between ticket prices of incumbent operators and entrant operators on routes where they operate under open access competition on country and aggregate level?

Are average ticket prices on routes with open access competition lower compared to routes without open access competition on country and aggregate level?

What is the effect of open access competition in the long distance passenger rail market and the booking day on rail ticket prices?

In this paper we first dram a theoretical framework based on existing literature where we explain the liberalisation process of the EU passenger rail market, the difference between intermodal and intramodal competition, the forms in which intramodal rail competition exists and insights from previous research on open access competition in the rail passenger market. Next, we explain what data we use in this paper and how we obtained this data. Afterwards, we elaborate on the methodology we use to perform our analyses. We continue with our results. Hereby we first answer the sub questions on country level, then we answer the sub questions on aggregate level, and last we answer our main question by running an OLS regression. We end this paper with a conclusion and discussion.

2. Literature review

2.1. Liberalisation of the EU railway market

The rail sector contributes strongly to the European economy. The estimated gross value added of the entire industry in the EU is 143 billion euro, while employing around 2.3 million people (Gleave, 2015). Railways fulfil multiple societal objectives as well, such as the provision of connectivity and a substitute to road and air modes. Due to this significant contribution the rail market is a topic of public interest. Railways were governed in public control enforced by law in most countries (Feuerstein et al., 2018). As a result in many countries the railways are still publicly owned and regulated. Vertically integrated railway companies were seen as a monopoly due to their presupposed economies of scale (Beria et al., 2012). However, this perception has changed and nowadays only the rail infrastructure is considered as a monopoly. From this moment the possibility of competition has been enabled, since the management and ownership of the network infrastructure is separated from the operation of services (Alexandersson, 2009).

Competition in the railway market has traditionally been limited in Europe (Casullo, 2016). Competition should result in efficiencies leading to lower fares and better connections. However, theories of competition are often neglected by market characteristics in favour of a monopoly, such as the availability of train paths, market potential, low profitability, infrastructure cost and access to rolling stock (Feuerstein et al., 2018). Only in recent years open competition occurred in a larger scale. Between 2001 and 2016 the EU adopted four legislative packages with the aim of opening rail markets for transport (European Commission, 2021). From 25th December 2023 governments and networks need to meet additional conditions to allow for direct granting of concession (EU PSO 2016/2338). Moreover, the packages include the opening of the international and domestic passenger markets to new entrants. Companies would be able either to offer competing services or to bid for public service rail contracts (PSO contracts) through competitive tendering. Multiple countries have already partly or entirely implemented this legislation. At the time of writing approximately half of European countries allow for open access competition, but only in some countries this already takes place (Casullo, 2016). PSO contracts via competitive tendering on the contrary barely exist in the long distance traffic and are somewhat more common in regional traffic.

2.2. Competition in the railway market

For our analysis of competition in the railway market it is important to distinguish between intermodal and intramodal competition. On long distance routes HSR services often act as a substitute to airplane services, but also cars and coach services should be taken into account. This paper mainly focusses on intramodal competition, which exists via competitive tenders and open access. Both forms of competitions are described shortly in the next sections.

2.2.1. Intermodal competition

HSR transport competes with air transport over a wide range of distances, namely between 400 and 2.000 kilometres (Milan, 1993). For instance, research shows the high substitutability on the Madrid – Barcelona line. The HSR market share was expected to reach a market share between 40% and 60% (Gonzales-Savignat, 2004). Moreover, the willingness to pay is higher for HSR services compared with air services (Martín & Nombela, 2007). Another example is het London – Paris line. Research shows that HSR services are in competition with airplane services and that the number of airplane services reduces in favour of HSR services (Behrens & Pels, 2012). Other research found that air and rail companies change their pricing strategies when budget operators enter the market (Antes et al., 2004). In addition, a small number of competitors is enough to create a high level of inter- and intramodal competition (Ivaldi & Vibes, 2005). Another interesting finding is that airline fares can be lower than

HSR fares. Since travel time is the most important factor for determining the demand, the HSR operator can increase fares without losing a significant market share (Gleave, 2006). In line with this, airline fares decrease when rail speed increases and when airport access time increases. Travel time of HSR is the most important determinant to successfully compete with airplane services (Yang & Zhang, 2012). In contrast, HSR and airplane services can also act as complements to each other. Airlines can use HSR as an additional spoke in their network (Giovani & Banister, 2006). Last, research shows that airlines significantly reduce prices when flights are in direct competition with HSR services (Bergantino et al., 2015).

2.2.2. Intramodal competition

Intramodal competition in HSR services can be categorised in two categories, namely competitive tenders (PSO contracts) and open access competition. In competition under competitive tenders operators compete by bidding to get the exclusive monopoly rights to operate all services on a specific market. Open access competition can be described as competition for the market, where operators compete on the tracks, on the same routes for the same customers at the same time (Feuerstein et al., 2018). PSO contracts via competitive tenders are common in Europe, however mostly in regional traffic and not in long distance traffic (Casullo, 2016). Competitive tendering is only applied to the full long distance domestic rail market in Sweden and GB and on parts of the network in Denmark and Estonia. Regionally, competitive tendering can be observed in CZ, Denmark, Germany, Italy, The Netherlands, Poland, Portugal, Slovakia, Sweden and GB. In all other countries in the EU all exclusive rights to operate rail services are directly awarded to the incumbent. Open access competition on the long distance network is allowed in Austria, Bulgaria, CZ, Denmark, Estonia, Germany, Italy, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Spain, Sweden and UK. However, it can only be observed on mediate or large scale in Austria, CZ, Germany, Italy, Spain, Sweden and UK.

PSO contracts exist in multiple forms that differ in the allocation of tasks and responsibilities between granting governments, transport carriers and infrastructure operators. Table 1 provides an overview of most common competitive tendering models (MuConsult, 2021). In the integral model all tasks and responsibilities are put at the carrier. This means that at the end of a concession the entire railway infrastructure and vehicles may move to another operator. In this case a large amount of contracting is needed to safeguard a smooth implementation of the new operator. This model is applied to Switzerland. In the Scandinavian model the carrier is responsible for the transport. All other tasks, including the management of all vehicles, infrastructure and all support activities, are the responsibility of the tendering institution or the government. This allows the government to have a high level of control on the network. The directing model is quite similar to the Scandinavian model. The carrier is responsible for the transport, but a private party is responsible for all other activities. This model is applied to the suburban transport in Utrecht. In the mixed model the carrier performs the transport, support and the development of the network. The management of rail vehicles and the exploitation of stations may be done by either the carrier or a public party. The public party is responsible for managing the infrastructure. This model is applied to the Dutch railway sector. Last, in the delegating model the carrier is responsible for the transport and a public party for all other tasks. This model is commonly applied in regional PSO contracts in Germany.

Table 1. Overview of competitive tendering models.

Task	Integral model	Scandinavian model	Directing model	Mixed model	Delegating model
Transport	Carrier	Carrier	Carrier	Carrier	Carrier
Asset management and maintenance rail vehicles	Carrier	Government	Private party	Carrier/public party	Public party
Asset management and maintenance rail infrastructure	Carrier	Government	Private party	Public party	Public party
Support (e.g. travel information and marketing)	Carrier	Government	Private party	Carrier	Public party
Development of network and services	Carrier	Government	Private party	Carrier	Public party
Exploitation stations	Carrier	Government	Private party	Carrier/public party	Public party

PSO contracts under competitive tendering exist in multiple financial forms. Some examples are the gross cost contract, where the operator receives a subsidy that covers all costs and includes a marginal profit. Passenger revenue directly flows to the tendering governmental organisation. Another example is the net cost contract. The operator then receives the passenger revenue and an optional additional net positive subsidy or has to pay an exploitation fee in case of high revenues. In general, operators bid for the lowest price they can offer to perform their tasks and responsibilities when the operator is a net receiver of subsidies or bid for the highest operating fee they pay to the governmental tendering organisation if a concession is highly profitable. However, operators are not in direct competition. Ticket prices are often capped, but there is no incentive to lower ticket prices.

On the other hand, open access competition is the other form of intramodal competition. Open access competition can be interpreted as direct competition between carriers on the same route, for the same passenger market and at the same time. Two types of open access competition can be observed in Europe (Tomes et al., 2016). The first is competition in the niche market, which can be observed in Germany and the UK. Research shows that the open access competition in the UK was suboptimal and strongly regulated to avoid threatening the financial position of the PSO contracts (Jones, 2000). Potential entrants must proof that they are serving a new market and will not steal customers from existing franchises. Thus, there is no real direct competition under this presence of open access. Germany divided its domestic rail market in regional submarkets and the long distance market (Tomes et al., 2016). The regional markets are often subsidised and granted under PSO contracts by competitive tendering. The long distance market is not subsidised and fully liberalised under open access competition. However, the incumbent Deutsche Bahn has a dominant market share of approximately 99% (Deville & Verduyn, 2012). From 1994, there were ten entries of new operators (Séguret, 2009). However, most of them failed and only two carriers are operating in niche markets, because of high infrastructure charges, hidden integration of long distance and regional transport and discrimination of new entrants by DB (Tomes et al,. 2016).

The second type of open access competition is entry of a competitor on a main railway route with high demand and passenger numbers (Tomes et al., 2016). Here operators indeed compete on the same route for the same customers at the same time. In Sweden open access is allowed on the entire network. However due to the low profitability open access only operates on some routes. An operator entered the market on the Stockholm – Göteborg/Malmö routes between 2008 and 2010 by differentiating in price, comfort and frequencies. Intermodal market share for trains increased and fares decreased, but after two years the entrant stopped its operations in Sweden (Fröid and Byström, 2013). In 2015 MTR entered the Swedish market on the Stockholm – Göteborg route and is now successfully competing with SJ. In Italy open access operated on the HSR lines. This lead to a decrease in fares of approximately 30%, higher frequency, an increase in service level and a significant increases in passenger numbers (Cascetta & Coppola, 2014). In Austria open access operates on the main line between Vienna and Salzburg. As a result of the competition the frequency on this line increased and the entrant offered lower fares (Tomes et al., 2016). This research also states that multiple studies (e.g. Ivaldi & Seabright, 2003) conclude that open access benefits passengers by lower ticket prices, higher frequencies and better service. On the other hand, operators under open access are often unprofitable, since competition usually results in unsustainable price wars and the decline of economies of scale advantages leading to the exit of one of the competitors. For example, this happened in Slovakia in 2017 when RegioJet exit the market due to the absence of sustainable profitability (Kvizda, 2019). In consistency with this, on track competition has not led to significant efficiency improvements despite entrants having lower unit costs than incumbents (Casullo, 2016). According to this research, unit costs could even rise due to the lack of guarantees on non-discriminatory access. This puts the sustainable position of operators competing under open access further under pressure.

3. Data collection

In rail transport publicly available data on passengers and prices are scarce. If data is available it is aggregated for multiple years and entire networks. Details on specific dates and connections are not publicly available. In order to analyse price strategies of carriers on route and date level we obtain data from the booking websites of the carriers competing on a particular route by manual web scraping. We collect data on ticket prices at one specific time stamp for a booking horizon of 1 to 30 days ahead of departure. For Austria we ran queries on tickets.oebb.at and westbahn.at on 4 July 2021. Thus, the data is for the period from 5 July 2021 until 3 August 2021. The CZ data has been collected from cd.cz, regiojet.com and leoexpress.com on 5 June 2021 for the period from 6 June 2021 until 5 July 2021. Data on the Italian trains and prices has been obtained from trenitalia.com and italotreno.it on 7 June 2021 for the period from 8 June 2021 until 7 July 2021. The railway fares in Spain are provided by renfe.com and ouigo.com on 1 June 2021 for the period from 2 June 2021 until 1 July 2021. Last, for Sweden we employed the booking sites sj.se and mtrx.travel on 4 July 2021 for the period from 5 July 2021 until 3 August 2021. Data for Austria and Sweden is obtained later compared to the other countries. In Austria ticket prices were effected by temporary price agreements due to Covid-19 with the government, while in Sweden major engineering works impacted time tables and ticket prices before July 2021.

For these countries we analyse daily average ticket prices of origin destination pairs, in particular for the connection of the incumbent operator under direct competition and the same connection for the entrant operator under direct competition. This can be seen as our treatment group. Also, we look at origin destination pairs on connections that only the incumbent operates without direct competition. This can be seen as our control group. The origin destination pairs for both are chosen to be representative for the market situation, although is some cases, such as in Italy, direct competition can be found on other connections as well. In Austria we study the Wien – Salzburg route with direct open access competition. We compare the ticket prices on this connection with the Wien – Graz, Wien – Klagenfurt and Innsbruck – Klagenfurt routes. These connections act as our control group without direct open access competition, since only the incumbent operates these routes. In CZ we choose the Praha – Ostrava route to study direct competition under open access. We compare this to the Praha – Plzen, Praha – Usti and Labem and Praha – Ceske Budejovice routes, which act as our control group without competition. In Italy we study the Milano – Roma route under competition. The Milano – Ancona, Turin – Venice and Roma – Bari connections act as control group, since the entrant carrier does not operate or operates limited on these routes. In Spain we study the Barcelona – Madrid route under direct competition. We use Madrid – Alicante, Madrid – Valencia, Madrid – Malaga and Madrid Seville as control routes. Last, in Sweden we study open access competition on the Stockholm – Göteborg connection. As control group we use Stockholm – Malmö and Göteborg – Malmö.

Starting at one booking day before departure, we simulate a booking request on every route for every specific departure until we reach the date of travel which lies thirty booking days ahead of travel. We always collect the lowest one-way fare available for every single departure in one direction for an adult without discount irrespective of booking class and cancelling conditions. For all operators we only considered direct HSR or in some countries equivalent direct fast trains with approximately equivalent travel times, since numerous direct HSR and fast trains are available on all routes. We excluded trains which are diverted and do not use the fastest routes, since longer routes are more expensive in general. Interchanging trains is highly unlikely in the presence of direct trains, because itineraries with interchanging connections often have a longer travel time and usually are more expensive. For this reason we only take direct services in consideration. Regional trains are excluded since they are often subsidised. National PSO fast trains are included, since they are commonly used exactly as in the market segment and their price may be capped but is not fixed.

This procedure resulted in a dataset per operator and per route that contains the lowest fare available on every specific departure within the period of one booking day in advance until thirty days in advance. This enables us to compare pricing strategies under intra-modal competition with pricing strategies under intra-modal monopoly. Moreover, we collect data on the number of daily departures, travel distances and travel times. In total, we have 8.359 observations which we further aggregated to obtain daily averages of ticket prices per route and operator. The descriptive statistics on the data can be found in the ticket price analysis on country level section in chapter 5.

4. Methodology

In this section we explain the methodology of our research. We analyse the descriptive statistics such as average prices of our data set and run an OLS regression to investigate the pricing behaviour of the competing operators and to explore the effect of direct open access competition in the long distance passenger railway market.

4.1. Ticket price analysis on country level

For Austria, CZ, Italy, Spain and Sweden we observe the market for a booking horizon of thirty days, namely one day ahead of travel until thirty days ahead of travel. We do this for a main line where the incumbent and entrant compete directly under open access for the market. This route can be seen as the treatment group. We also observe the market similarly for some other main lines where only the incumbent operates, so without direct competition. These routes act as the control group. The routes in the control group are chosen to be representative for all main routes in the country. The average daily control price is defined as the average of the daily average price of all routes in the control group. In order to evaluate the pricing strategies among the incumbent and entrant, we compare the daily average of the lowest ticket price available for every single departure for the incumbent, entrant and the control routes. For each day in the booking horizon, *t*, we compute the average ticket price based on the lowest fare for each departure, *P,* offered by the incumbent, the entrant and the control route, P_t^I, P_t^E and P_t^C respectively. The definitions are as follows:

$$P_t^I = \frac{\sum_{i=1}^{n} P_{t,i}^I}{n}$$

$$P_t^E = \frac{\sum_{i=1}^{n} P_{t,i}^E}{n}$$

$$P_t^C = \frac{\sum_{i=1}^{n} P_{t,i}^C}{n}$$

Where $P_{t,i}^I$ is the lowest fare available on the specific train service *i* of the incumbent operator I*,* bought *t* days in advance. Thus, P_t^I is the average of the lowest prices available for each departure on the *n* train services scheduled on day *t.* The average prices of the entrant and the control routes are defined similarly.

Next, we analyse the descriptive statistics of this data on country level. We look at the correlation among the daily average fares of the incumbent and entrant. We specify this correlation for the full sample of 1 to 30 days ahead of departure, the period of 1 to 5 days ahead of departure, the period of 6 to 15 days ahead of departure and the period of 16-30 days ahead of departure. This enables us to study strategic price behaviour among the operators.

Afterwards, we perform paired t tests to investigate whether there is a significant difference between the average daily prices offered by the incumbent and entrant. The null hypothesis is that there is no difference between the average daily prices offered by the incumbent and the entrant. The alternative hypothesis is that the average daily prices of the entrant are lower than the prices of the incumbent. Hereby, the average fare of each booking day ahead of travel of the incumbent is compared with the average fare of the entrant on the same booking day ahead of travel. We again do this for the full sample of 1 to 30 days ahead of departure, 1 to 5 days ahead of travel, 6 to 15 days and 16 to 30 days. Thus, in this step we study whether there is a significant price difference between the competitors.

Last, we analyse the average daily price per kilometre of the incumbent and entrant operator to be able to compare this with the average daily price per kilometre of the control routes operated by the incumbent. Therefore, we perform paired t tests to investigate whether there is a significant difference between the average daily fares of the incumbent on the route under direct open access competition and the control routes on which it operates without direct competition. The null hypothesis is that there is no difference in the average daily price per kilometre of the incumbent under open access competition and without open access competition. The alternative hypothesis is that the average daily price per kilometre of the incumbent is lower under open access competition compared to the situation without open access competition. We also perform paired t tests to test whether there is a significant difference between the average daily prices of the entrant and the control routes operated by the incumbent. The null hypothesis is that there is no difference in the average daily price per kilometre of the entrant under open access competition and other routes without open access competition. The alternative hypothesis is that the average daily price per kilometre of the entrant is lower under open access competition compared to other routes without open access competition. Again, we do this for the full sample, 1 to 5 days ahead of departure, 6 to 15 days and for 16 to 30 days. Thus, in this step we compare the average ticket prices in the competitive market to the ticket prices in the non-competitive market.

4.2. Aggregate ticket price analysis

In this part we aggregate all data we collected for our research on the effect of open access competition on ticket prices on country level. We use price data per kilometre to be able to compare different routes in different countries. We create four variables, namely the booking day ahead of departure, the daily average ticket price per kilometre of the incumbent, the daily average ticket price of the entrant and the control price per kilometre. We now investigate the correlation among the incumbent and entrant fares in order to evaluate if there exists a general relationship in reactive pricing behaviour between incumbents and entrants. We calculate the correlation for the full sample, so for 1 to 30 booking days ahead of travel. We also define it for the periods of 1 to 5 booking days ahead of departure, 6 to 15 days and 16 to 30 days.

Next, we perform paired t tests to investigate whether there is a significant difference between the average daily prices offered by the incumbents and entrants. The null hypothesis is that there is no difference between the average daily prices offered by the incumbents and the entrants. The alternative hypothesis is that the average daily prices of the entrants are lower than the prices of the incumbents. Hereby, the average fare of each booking day ahead of travel of the incumbent is compared with the average fare of the entrant on the same booking day ahead of travel. Incumbents and entrants are compared in pairs per country, to acknowledge the differences in kilometre prices between countries. We again do this for the full sample of 1 to 30 days ahead of departure, 1 to 5 days ahead of travel, 6 to 15 days and 16 to 30 days. Thus, in this step we study whether there is a significant price difference between the competitors.

Now, we analyse the average daily price per kilometre of the incumbents and entrants under direct access competition to be able to compare these with the average daily price per kilometre of the control routes operated by the incumbent without competition. Therefore, we perform paired t tests to investigate whether there is a significant difference between the average daily fares of the incumbents on the route under open access competition and the control routes on which they operate. The null hypothesis is that there is no difference in the average daily price per kilometre of the incumbent under open access competition and without open access competition. The alternative hypothesis is that the average daily price per kilometre of the incumbent is lower under open access competition compared to the situation without open access competition. We also perform paired t tests to test whether there is a significant difference between the average daily prices of the entrants and the control routes operated by the incumbents. The null hypothesis is that there is no difference in the average daily price per kilometre of the entrant under open access competition and other routes without open access competition. The alternative hypothesis is that the average daily price per kilometre of the entrant is lower under open access competition compared to other routes without open access competition. Again, incumbents and entrants are compared in pairs per country and we do this for the full sample, 1 to 5 days ahead of departure, 6 to 15 days and for 16 to 30 days. Thus, in this step we compare the average ticket prices in the competitive market to the ticket prices in the non-competitive market while distinguishing among the incumbent operator and entrant.

Last, we further aggregate the data and no longer distinguish between incumbents and entrants. We create two variables, namely the average fare per kilometre under open access competition, which is our treatment group, and the average fare per kilometre without open access competition, which is our control group. Note that we are still working with data from the five countries we started with. Thus, the variable with open access competition consists of all daily averages of all observations of connections under open access competition, while the variable without open access competition consists of all daily averages of all observations of connections from the control group. We perform paired t tests to test whether there is a significant difference between the ticket prices under open access competition and the ticket prices not under open access from the control group. We match the two variables by booking day per country. The null hypothesis is that there is no difference between the average ticket prices under open access competition compared to the average ticket prices not under open access competition. The alternative hypothesis is that the average ticket prices under open access competition are lower compared to the average ticket prices not under open access competition. We do this for the full sample, 1 to 5 days ahead of departure, 6 to 15 days and for 16 to 30 days. Thus, in this step we compare the average ticket prices in the competitive market to the ticket prices in the non-competitive market in general.

In the last step of our analysis we run an OLS regression to measure the effect of open access competition on average ticket prices in the long distance passenger railway market. This regression is partly based on earlier research to intermodal competition among long distance trains and airlines (Bergantino et al., 2015). We define our equation as follows:

$$\ln(P_{ijt}) = \beta_0 + \beta_1\ Open\ access\ competition_{ij} + \beta_2\ Booking\ day_t + \beta_3\ Booking\ Day_t^2 + \beta_4\ Control\ variables + u_{ijt}$$

where *i* indexes the route, *j* the carrier and *t* the booking day ahead of departure. The value of *t* goes from 1 day until 30 days of departure. The dependent variable is the log of the average price of the lowest fare available for each departure on route *i* with carrier *j* on booking day ahead of departure *t*. The variable *Open access competition* is a dummy with value 1 if carrier *j* on route *i* operates under direct open access competition and value 0 if carrier *j* on route *i* operates without competition. We expect this variable to have a negative coefficient since competition in general puts downward pressure on ticket prices. The variable *Booking day* quantifies the effect of the intertemporal price effect on fares. Its value ranges from 1 to 30 days ahead of travel. We expect this variable to have a negative coefficient as ticket prices tend to be lower when booked more days in advance. The square of the *Booking day* is added to the equation to control for the non-monotonicity of *Booking day* (Bergantino & Capozza, 2015). We also use particular *Control variables* to avoid bias in our model, in particular the *Population* and the *GDP per capita*. Finally, u_{ijt} is the error term in the equation.

5. Results

Our analysis of intra-modal railway competition and its effect on long distance rail ticket prices is built on data from countries that allow for competitive tenders on the long-distance market or open access and where this competition actually exists. These countries are Austria, CZ, Germany, Italy, Spain, Sweden and UK (Casullo, 2016 & CNMC, 2019).

First, we analyse the price strategy of the incumbent and entrant operator for each country and compare this with routes on which only the incumbent operates. Second, we aggregate all data to investigate pricing strategy under open access competition in general.

5.1. Ticket price analysis on country level

In this section we investigate the pricing strategies of incumbent and entrant operators that compete on the main lines under open access. Countries included in this analysis are Austria, CZ, Italy, Spain and Sweden. We also included Spain, although HSR services are performed under a PSO contract under competitive tendering. However, in practice, in Spain multiple operators compete on the same tracks, on the same routes for the same customers at the same time. We excluded Germany and UK, since carriers only operate there under open access competition in niche markets.

5.1.1. Austria

In Austria open access competition can be observed on the main line of the country, namely between Wien and Salzburg. Since 2011 the new entrant Westbahn competes with the incumbent operator ÖBB. The trains cover a distance of approximately 300 kilometres with speeds up to 230 km/h between 2 hours and 22 minutes and 3 hours and 6 minutes, depending on the number of intermediate calls. Daily 51 direct services run in each direction between Wien and Salzburg, from which 37 services are running under the RailJet brand of incumbent ÖBB. The other 14 services are operated bij Westbahn. This means that incumbent ÖBB maintains the highest market share of 72.5%, while Westbahn accounts for 27.5%. Table 2 summarises the context characteristics of the open access competition on the Wein – Salzburg route. This is the only connection in Austria where carriers operate under open access competition. All other long distance routes are operated by incumbent carrier ÖBB, although open access competition is allowed on the entire long distance market.

Table 2. Context of rail services under open access competition in Austria.

Route	Distance (km)	Carrier	Time (h)	Daily services	Market share
Wien - Salzburg	300	ÖBB	2.22-2.53	37	0.725
		Westbahn	2.26-3.06	14	0.275

ÖBB and Westbahn have a different price strategy. In general, the Westbahn fares are lower than the ÖBB fares. ÖBB offers different types of tickets regarding comfort, services and flexibility. Connections may vary in price and higher travel classes are more expensive. The lowest fare can be booked in advance, is only valid on one specific connection and is non-refundable. The price of this fare rises if there is more demand for a specific train. Refundable tickets are more expensive and their price is based on the travel distance and capped. Subscription holders get a 50% discount on this flexible fare. Westbahn tariffs have the same price structure as ÖBB. Prices differ among connections, the chosen comfort, flexibility and demand for a specific train. Non-refundable pre-booked ticket are cheaper than flexible fares on the day of booking. Interestingly, Westbahn offers ÖBB subscription holders a discount. Therefore, Westbahn's flexible tickets are still cheaper than the flexible ticket with discount valid for ÖBB services. As shown in table 3, the average daily fare of ÖBB, based on the cheapest fare available for every connection, is approximately €28.30. Westbahn offers lower fares on average, namely approximately €17.70. The average minimum fare available per day is quite similarly between the carriers with €15.57 for ÖBB and €14.49 for Westbahn. Note that the average minimum fare of Westbahn is close to its average daily fare, meaning that relatively cheap tickets for Westbahn connections have a good availability. Instead, the daily average fare of ÖBB is more expensive. The average maximum fare of ÖBB is €51.66 and €23.49 for Westbahn.

Table 3. Descriptive statistics of the ÖBB and Westbahn fares on the Wien – Salzburg route.

Route	Carrier	Mean	Std. Dev.	Min.	Max
Wien - Salzburg	ÖBB	28.302	5.289	15.566	51.660
	Westbahn	17.698	2.321	14.490	23.490

In figure 1 the temporal profiles of the average daily fares of ÖBB and Westbahn are shown. Consistent with table 3, the development of the fare of ÖBB has a larger standard deviation compared to Westbahn. Thus, prices at ÖBB vary more per travel date compared to Westbahn, which has a more consistent pricing strategy. Over time, both ÖBB and Westbahn average ticket prices become cheaper if booked more days in advance of departure.

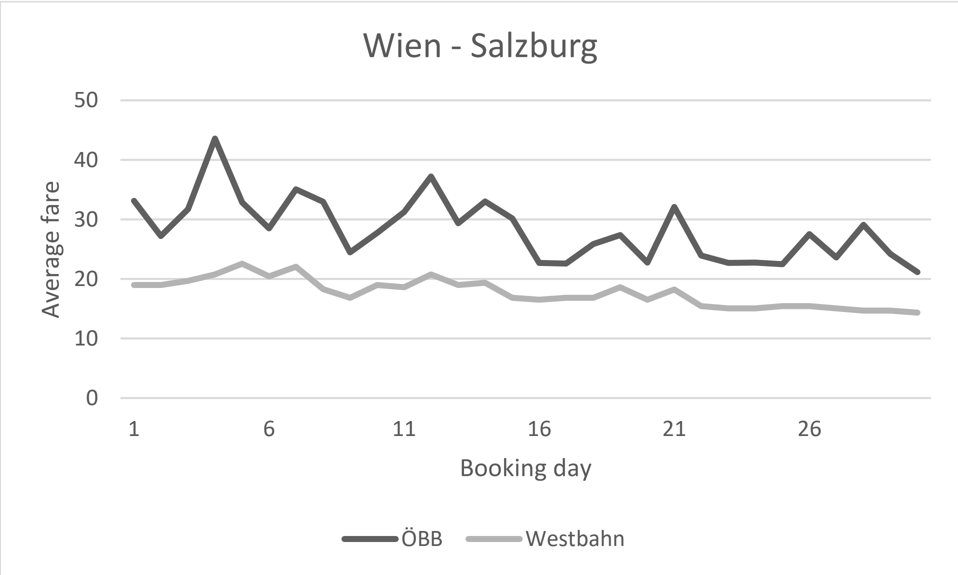

Fig. 1. Temporal profiles of ticket prices on the Wien – Salzburg route. Source: Analysis of price data from operator's website.

In table 4 the relationship between ÖBB and Westbahn fares on the Wien – Salzburg route is shown. Generally, operators are more likely to take into account the pricing behaviour of the competitor when the day of travel approaches. However, this cannot be observed on the Wien – Salzburg route. Correlation might differ depending on the booking day, which implies that both operators adopt a pricing strategy that diverges along with the days of departure. Over the full booking horizon, the ÖBB and Westbahn fares have a highly significant correlation of 0.78. This means that there is a strategic reaction in pricing behaviour among the competitors. In the period of 1-5 days before departure there is no significant sign of a correlation between the fares of ÖBB and Westbahn. In the period of 6-15 days before departure we find a significant correlation of 0.63. In the period of 16-30 days ahead of departure this correlation decreases to a value of 0.48.

Table 4. Correlation among ÖBB and Westbahn fares on the Wien – Salzburg route.

		Booking day		
Route	Full sample	1-5	6-15	16-30
Wien - Salzburg	0.776***	0.363	0.631*	0.477*

*** p<0.01, ** p<0.05, * p<0.1

The average ÖBB fare over the full sample of booking days is significantly higher than the Westbahn fare, namely €28.30 and €17.70 respectively. Thus, significantly, Westbahn tickets are on average €10.60 cheaper than ÖBB tickets on the same day of departure. For both carriers tickets are more expensive when the day of booking is close to the day of departure, as is shown in table 5. Tickets booked between 1 and 5 days ahead of departure cost on average €33.70 at ÖBB and €20.20 at Westbahn. This is a significant difference of €13.50. When booked 6 to 15 days before departure the ÖBB price decreases to €30.98, while the Westbahn average fare decreases to €19.12. This makes Westbahn a significant €11.86 cheaper compared to ÖBB in this period. Booked 16 to 30 days ahead of travel the ÖBB and Westbahn ticket prices further decrease to €24.72 and €15.92 respectively. In this period Westbahn is on average €8.80 cheaper than ÖBB. Note that the price difference between the incumbent and the entrant decreases when the day of departure lies more ahead of the day of booking.

Table 5. Average price differences between ÖBB and Westbahn on the Wien – Salzburg route. Paired t-test performed on the average price differences between the carriers on the same booking day.

Route Wien – Salzburg Booking days	Average fare ÖBB	Average fare Westbahn	Difference
Full sample	28.302	17.698	-10.604***
	(0.966)	(0.424)	(0.691)
1-5	33.700	20.204	-13.496***
	(2.690)	(0.674)	(2.525)
6-15	30.980	19.119	-11.861***
	(1.183)	(0.522)	(0.945)
16-30	24.717	15.915	-8.802***
	(0.788)	(0.334)	(0.694)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In table 6 the average price differences per kilometre among ÖBB, Westbahn and the control fare are shown. Consistent with table 5, the average price per kilometre of ÖBB and Westbahn on the Wien – Salzburg route as well as the average price per kilometre on the control routes Wien – Graz, Wien – Klagenfurt and Innsbruck – Klagenfurt decreases when booking more days ahead of travel. We observe that the ÖBB prices on the Vienna – Salzburg route under open access are not significantly lower than prices on routes where the incumbent operates without open access competition. On the other hand, the Westbahn prices are significantly lower than the control price. For the full sample we observe a difference of €0.04 per kilometre, which is a decrease of 37% compared to the control fare. In the booking period of 1-5 days ahead of departure the difference even amounts €0.06, which is equal to a decrease of 44% compared to the control fare. Consistent with the difference in price between ÖBB and Westbahn, the difference between the Westbahn price per kilometre and the control fare decreases when the booking horizon grows. In the periods 6 to 15 and 16 to 30 days ahead of departure Westbahn is €0.04 and €0.03 significantly cheaper per kilometre compared to the control fare. Thus, we find that ÖBB ticket prices do not differ on the presence of open access competition. However, the average ticket price of Westbahn is significantly lower compared to the fares of incumbent ÖBB on routes without competition.

Table 6. Average price differences per kilometre among ÖBB, Westbahn and the control fare. Paired t-test performed on the average price differences between ÖBB and the control fare and between Westbahn and the control fare.

Booking days	Avg. Fare ÖBB	Avg. fare Westbahn	Control fare	Difference ÖBB and control fare	Difference Westbahn and control fare
Full sample	0.0956	0.0598	0.0960	-0.0004	-0.0363***
	(0.0033)	(0.0014)	(0.0040)	(0.0043)	(0.0036)
1-5	0.1139	0.0683	0.1241	-0.0102	-0.0558**
	(0.0091)	(0.0023)	(0.0159)	(0.0195)	(0.0175)
6-15	0.1047	0.0646	0.1001	0.0045	-0.0355***
	(0.0040)	(0.0018)	(0.0036)	(0.0064)	(0.0044)
16-30	0.0835	0.0538	0.0840	-0.0005	-0.0302***
	(0.0027)	(0.0011)	(0.0026)	(0.0043)	(0.0023)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.1.2. Czech Republic

On the Praha – Ostrava line three carriers directly compete. This is a unique situation on the railway market at this time, where three operators compete on the same route without direct subsidies. The incumbent carrier is ÇD. In 2011, competitor RegioJet entered the market. In first instance, the entrant offered lower prices and more consistent and standardised service than the incumbent. ÇD responded by lowering its prices and providing more comfort. In 2013, operator Leo Express entered the Czech railway market, again with low prices and standard quality provided on board of their trains. In general, prices differ among the carriers. Travel class is an important determinant in ticket prices. Peak travel times result in higher prices, while trains with a lower demand have lower prices. Prices also differ for the product chosen. Flexible tickets are more expensive than non-refundable tickets which are only valid on a specific service. An overview of services on the Praha – Ostrava line is presented in table 7. ÇD operates 15 daily services which equals approximately 46.9% of market share. RegioJet offers 11 daily connections with a market share of 34.4%, while Leo Express runs 6 services a day with a market share of 18.7%. Carriers in CZ operate under open access competition on the side-branch to Brno and some international routes as well. We study the Praha – Ostrava line as it is the most important line.

Table 7. Context of rail services under open access competition in CZ.

Route	Distance (km)	Carrier	Time (h)	Daily services	Market share
Praha - Ostrava	350	ÇD	3.21-3.38	15	0.469
		RegioJet	3.26-3.37	11	0.344
		Leo Express	3.30-3.46	6	0.187

In table 8 the descriptive statistics of the operators on the Praha – Ostrava route are shown. Leo Express has the highest ticket prices on average, namely €14.35. The mean of the lowest fares of ÇD is €12.96. RegioJet offers the lowest prices on average with a mean of €11.94. This operator also has the lowest average minimum per day, namely €8.12. ÇD and Leo Express have an average minimum daily fare of €9.93 and €11.05 respectively. Interestingly, RegioJet also has the highest average maximum fare of €19.44 per day. This may imply that RegioJet has the most aggressive pricing strategy of the three carriers. On trains with low demand the offer a relatively low price, while trains with more demand are more expensive compared to the other carriers. The highest average maximum price equals €15.83 for ÇD and €17.97 for Leo Express.

Table 8. Descriptive statistics of the ÇD, RegioJet and Leo Express fares on the Praha – Ostrava route.

Route	Carrier	Mean	Std. Dev.	Min.	Max
Praha - Ostrava	ÇD	12.955	1.495	9.927	15.829
	RegioJet	11.944	1.792	8.120	19.440
	Leo Express	14.352	3.830	11.047	17.970

The temporal profiles of the ticket prices of the carriers on the Praha – Ostrava line are shown in figure 2. In general, ticket prices do not become lower when booked more days in advance. Only Leo Express seems to offer higher ticket prices shortly before departure. This may be correlated with the relatively low train supply provided by the operator that may cause scarcity. All carriers have a relatively high standard deviation, which means that average ticket prices differ among the booking and travel day.

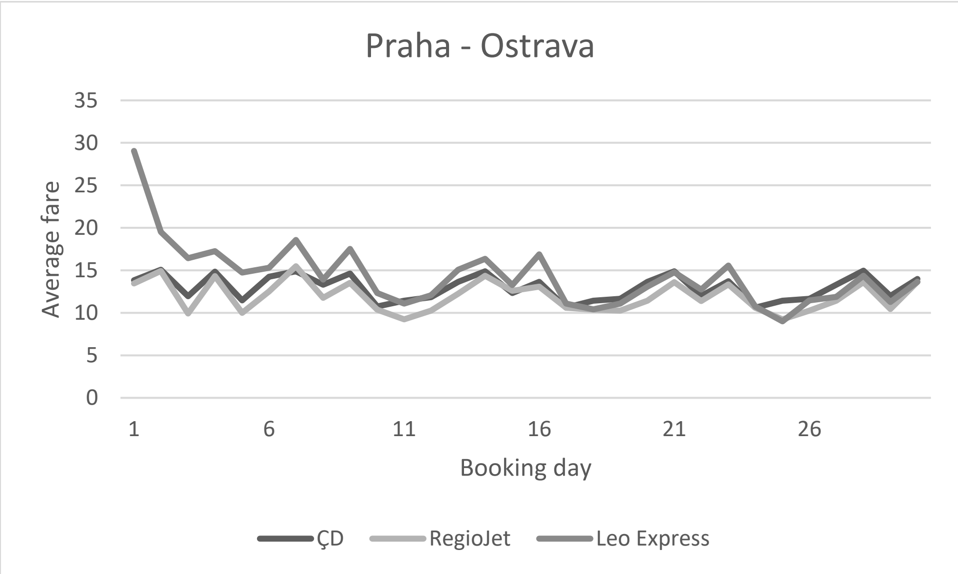

Fig. 2. Temporal profiles of ticket prices on the Praha - Ostrava route. Source: Analysis of price data from operator's website.

In table 9 the correlation between the ticket prices of ÇD, RegioJet an Leo Express is stated. We find a large and significant correlation among the ÇD and RegioJet ticket prices. For the full sample the correlation is 0.90. For the booking periods of 1 to 5, 6 to 15 and 16 to 30 days before departure the correlations are 0.99, 0.88 and 0.88 respectively. Thus, we observe strategic pricing behaviour among ÇD and RegioJet for the entire booking horizon of 1 to 30 days which means that both carriers adopt their ticket prices among the fares of each other. For both ÇD and RegioJet we find a mediate and significant correlation with Leo Express. For the full sample the correlation is 0.61 and 0.67 respectively. Interestingly, we find no correlation in the booking horizon of 1 to 5 days ahead of departure. This could be explained by the fact that Leo Express is a sort of a premium carrier that competes for a large part on service. Pricing competition could be a less determinant factor in their strategy.

Table 9. Correlation among ÇD, RegioJet and Leo Express fares on the Praha – Ostrava route.

Route Praha - Ostrava		Booking day		
Carrier	Full sample	1-5	6-15	16-30
ÇD – RegioJet	0.900***	0.988***	0.883***	0.876***
ÇD – Leo Express	0.612***	0.388	0.925***	0.791***
RegioJet – Leo Express	0.667***	0.460	0.943***	0.904***

*** p<0.01, ** p<0.05, * p<0.1

In table 10 we find the average price differences between ÇD and RegioJet and between ÇD and Leo Express. We find that the average prices of entrant RegioJet are significantly lower compared to ÇD, namely a difference of €1.01. The difference between average prices of these companies is smaller when booked shorter prior to departure. The difference is €0.89 on average when booked in the period of 1 to 5 days ahead of departure. This increases to €1.08 when a ticket is booked 16 to 30 days before departure. In contrast, looking at the full sample, entrant Leo Express is more expensive than incumbent ÇD. The difference in average ticket prices is €1.40. For the period of 1 to 5 days ahead of departure Leo Express is €5.97 more expensive on the Praha – Ostrava route than ÇD. For the booking period of 6 to 15 days before departure this difference decreases to €1.36. Booking 16 to 30 days ahead of departure we do not observe a significant difference between the average ticket prices of ÇD and Leo Express. Thus, we find that pricing competition is less strong shortly before departure and that ticket prices even may be increased. This may be explained by scarcity of trains and high demand.

Table 10. Average price differences between ÇD and RegioJet on the Praha – Ostrava route. Paired t-test performed on the average price differences between the carriers on the same booking day.

Route Praha - Ostrava Booking days	Average fare ÇD	Average fare RegioJet	Average fare Leo Express	Difference ÇD and RegioJet	Difference ÇD and Leo Express
Full sample	12.955	11.944	14.352	-1.011***	1.396**
	(0.273)	(0.327)	(0.699)	(0.144)	(0.574)
1-5	13.429	12.535	19.400	-0.894**	5.971**
	(0.738)	(1.077)	(2.533)	(0.366)	(2.347)
6-15	13.197	12.234	14.552	-0.963***	1.355***
	(0.482)	(0.610)	(0.775)	(0.292)	(0.377)
16-30	12.637	11.554	12.535	-1.082***	-0.101
	(0.377)	(0.388)	(0.559)	(0.191)	(0.349)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In table 11 we look at the price differences per kilometre among the carriers and compare this with the routes that act as control group, which compromises of the Praha – Plzen, Praha – Usti and Labem and Praha – Ceske Budejovice routes. We find that the fares of both incumbent ÇD and entrant RegioJet are significantly lower under direct open access competition compared to the ticket prices of incumbent ÇD on routes without competition. For the full sample the average prices of ÇD under open access competition are €0.010 lower than the fares which the operator offers without competition. The difference among entrant RegioJet and the control fare is even bigger, namely €0.010. For the, in general, more expensive operator Leo Express we find varying results. Looking at the full sample average prices of Leo Express are significantly lower compared to prices of incumbent ÇD on connections without competition, namely €0.003. For other booking periods the Leo Express fares are higher, the same or lower compared to the control routes. Thus, we find that, in general, in CZ ticket prices under direct open access competition are significantly lower than ticket prices without competition.

Table 11. Average price differences per kilometre among ÇD, RegioJet, Leo Express and the control fare. Paired t-test performed on the average price differences between ÇD and the control fare, between RegioJet and the control fare and between Leo Express and the control fare.

Booking days	Avg. fare ÇD	Avg. fare RegioJet	Avg. fare Leo Express	Control fare	Difference ÇD and control fare	Difference RegioJet and control fare	Difference Leo Express and control fare
Full sample	0.0370	0.0341	0.0410	0.0441	-0.0071***	-0.0100***	-0.0031**
	(0.0008)	(0.0009)	(0.0020)	(0.0004)	(0.0007)	(0.0008)	(0.0017)
1-5	0.0384	0.0358	0.0554	0.0463	-0.0080***	-0.0105***	0.0091*
	(0.0021)	(0.0031)	(0.0072)	(0.0017)	(0.0018)	(0.0024)	(0.0059)
6-15	0.0377	0.0350	0.0416	0.0438	-0.0061***	-0.0089***	-0.0022
	(0.0014)	(0.0017)	(0.0022)	(0.0007)	(0.0012)	(0.0016)	(0.0020)
16-30	0.0361	0.0330	0.0358	0.0436	-0.0075***	-0.0106***	-0.0078***
	(0.0011)	(0.0011)	(0.0016)	(0.0016)	(0.0010)	(0.0011)	(0.0016)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.1.3. Italy

In Italy we study open access competition on the Milano – Roma route. This connection is one of the most important routes of the country in passenger numbers and number of daily trains. On this route incumbent Trenitalia competes with entrant NTV which started its operations in 2012. The Milano – Roma route is one of the first connections which are operated under open access competition in large scale in Europe. NTV expanded its network throughout entire Italy and serves two main routes in competition with Trenitalia, in particular Milano – Roma and Milano – Venice. They serve many other large cities as well, but mostly with less daily trains than Trenitalia. On the Milano – Roma route travel times of Trenitalia and NTV are quite similar. Incumbent Trenitalia operated 34 daily services in each direction between the cities with a intramodal market share of 58.6%, while NTV operates 24 daily services with a market share of 41.4%. These statistics are stated in table 12.

Table 12. Context of rail services under open access competition in Italy.

Route	Distance (km)	Carrier	Time (h)	Daily services	Market share
Milano - Roma	570	Trenitalia	2.59-3.39	34	0.586
		NTV	3.04-3.39	24	0.414

In table 13 we find the descriptive statistics of the ticket prices of both Trenitalia and NTV on the Milano – Roma route. The average daily ticket price of Trenitalia is €87.05 with an average of lowest prices offered on each booking of €78.31 and an average maximum of €122.50. Entrant NTV offers fares of €73.65 on average with an average minimum of €71.47 and an average maximum of €78.94. Interestingly, the daily average ticket prices of Trenitalia are much more volatile compared to NTV.

Table 13. Descriptive statistics of the Trenitalia and NTV fares on the Milano – Roma route.

Route	Carrier	Mean	Std. Dev.	Min.	Max
Milano – Roma	Trenitalia	87.047	12.065	78.307	122.497
	NTV	73.645	2.764	71.467	78.937

In figure 3 the temporal profiles of average ticket prices on the Milano – Roma route can be found. We observe that the daily average ticket price of Trenitalia is higher that the daily average ticket price of

NTV for the entire booking horizon. We also find that Trenitalia increases its prices more shortly before departure compared to NTV.

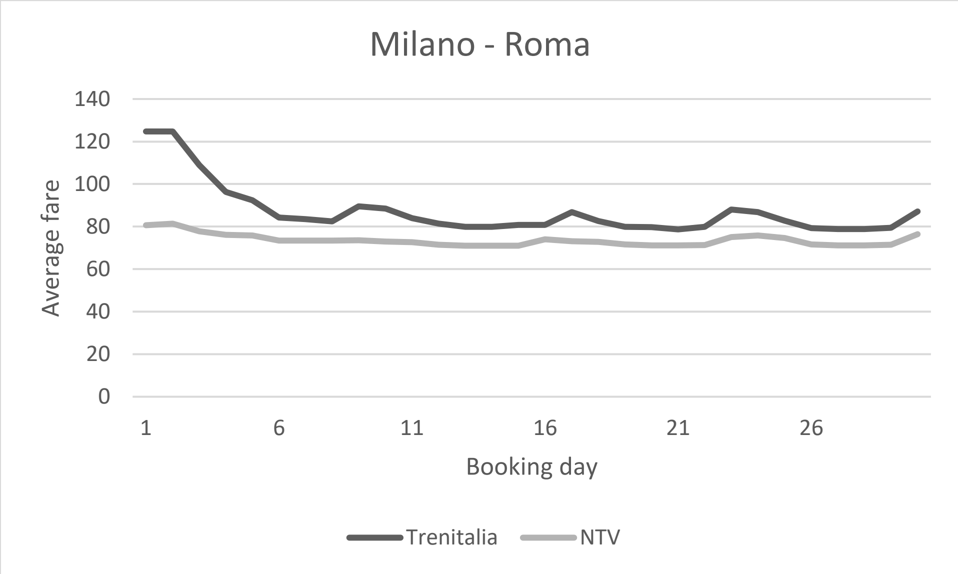

Fig. 3. Temporal profiles of ticket prices on the Milano – Roma route. Source: Analysis of price data from operator's website.

In table 14 we find the correlation among Trenitalia and NTV average ticket prices on the Milano – Roma route. The correlation between the fares of both operators is 0.92 for the entire booking horizon. We find a very high correlation of 0.99 in the booking period of 1 to 5 days before departure. This indicates a strong price reaction to the competitor's pricing strategy.

Table 14. Correlation among Trenitalia and NTV fares on the Milano – Roma route.

		Booking days		
Route	Full sample	1-5	6-15	16-30
Milano – Roma	0.919***	0.988***	0.753**	0.874***

*** p<0.01, ** p<0.05, * p<0.1

In table 15 we study the price differences between Trenitalia and NTV on the Milano – Roma route. We find that the average fares of entrant NTV are significantly lower compared to Trenitalia for all periods. For the full sample the average NTV prices are €13.40 lower than Trenitalia. Booking 1 to 5 days ahead of departure the average ticket price of NTV is €31.09 lower compared to Trenitalia. This decreases to a difference of €9.11 in the period of 16 to 30 days before departure. In Italy, many trains are fully booked shortly ahead of departure. This scarcity in capacity may enable both operators to raise their prices shortly ahead of departure.

Table 15. Average price differences between Trenitalia and NTV on the Milano – Roma route. Paired t-test performed on the average price differences between the carriers on the same booking day.

Route Milano – Roma Booking days	Average fare Trenitalia	Average fare NTV	Difference
Full sample	87.047	73.645	-13.403***
	(2.203)	(0.504)	(1.750)
1-5	109.454	78.367	-31.087***
	(6.809)	(1.132)	(5.693)
6-15	83.430	72.435	-10.995***
	(1.060)	(0.362)	(0.822)
16-30	81.990	72.877	-9.113***
	(0.895)	(0.484)	(0.528)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In table 16 we observe the price differences per kilometre among Trenitalia and NTV under open access competition and the routes that only Trenitalia operates without competition. We find that both the incumbent and entrant offer significantly lower prices under open access competition compared to the situation without competition for the full sample, in particular a difference of €0.017 and €0.040 respectively. The price difference is bigger shortly prior to departure compared to a booking day further ahead of departure. For example, Trenitalia ticket prices under open access competition are €0.061 lower than the situation without competition in the booking period of 1 to 5 days prior to departure. We do no observe a significant difference between these prices in the booking period of 16 to 30 days ahead of departure.

Table 16. Average price differences per kilometre among Trenitalia, NTV and the control fare. Paired t-test performed on the average price differences between Trenitalia and the control fare and between NTV and the control fare.

Booking days	Avg. Fare Trenitalia	Avg. fare NTV	Control fare	Difference Trenitalia and control fare	Difference NTV and control fare
Full sample	0.1527	0.1292	0.1693	-0.0166***	-0.0401***
	(0.0039)	(0.0009)	(0.0082)	(0.0047)	(0.0075)
1-5	0.1920	0.1375	0.2533	-0.0612***	-0.1158***
	(0.0119)	(0.0020)	(0.0176)	(0.0061)	(0.0157)
6-15	0.1464	0.1271	0.1615	-0.0152**	-0.0344***
	(0.0019)	(0.0006)	(0.0073)	(0.0056)	(0.0070)
16-30	0.1438	0.1279	0.1464	-0.0026	-0.0186***
	(0.0016)	(0.0008)	(0.0044)	(0.0036)	(0.0041)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.1.4. Spain

Spain opened its long distance HSR passenger market for open access competition in 2020. Since 2021 incumbent Renfe competes with entrant Ouigo on the Barcelona – Madrid route. Officially, there is no real open access in Spain, since the HSR services in the country are run under a PSO contract. After a competitive tender three operators are allowed to operate trains on the Spanish highspeed network. Renfe won package A, allowing the company to run 48 daily services in each direction on every route. At this moment Renfe operates on all routes, but with much less trains than allowed. Ilsa won package B, allowing the company to run 16 daily services in each direction on every route. It plans to commence operations in 2022 on the entire HSR network. Ouigo won package C, allowing the company to operate 5 daily services in each direction on every route. The company now operates only on the Barcelona –

Madrid route, but plans to expand its services to the entire network. This form of direct competition is quite similar to open access competition, for this reason we speak of open access competition for consistency of the paper.

In table 17 the statistics of the Barcelona – Madrid route can be found. Renfe offers 19 daily services with a market share of 79.2%, while Ouigo runs 5 daily trains in each direction with a market share of 20.8%.

Table 17. Context of rail services under open access competition in Spain.

Route	Distance (km)	Carrier	Time (h)	Daily services	Market share
Barcelona - Madrid	620	Renfe	2.30-3.17	19	0.792
		Ouigo	2.30-2.52	5	0.208

In table 18 the descriptive statistics of the ticket prices of Renfe and Ouigo on the Barcelona – Madrid route are shown. The average ticket price of Renfe is €64.62 and €40.63 for Ouigo. Interestingly, the average daily minimum fares are quite similar among the operators.

Table 18. Descriptive statistics of the Renfe and Ouigo fares on the Barcelona – Madrid route.

Route	Carrier	Mean	Std. Dev.	Min.	Max
Barcelona - Madrid	Renfe	64.616	8.483	31.888	91.053
	Ouigo	40.627	11.108	30.600	50.533

In figure 4 the temporal profiles of the ticket prices of Renfe and Ouigo on the Barcelona – Madrid route are shown. We observe that the average Renfe price is always higher than the Ouigo price. Moreover, we do not see an obvious increase in ticket prices when the departure comes closer to the day of booking.

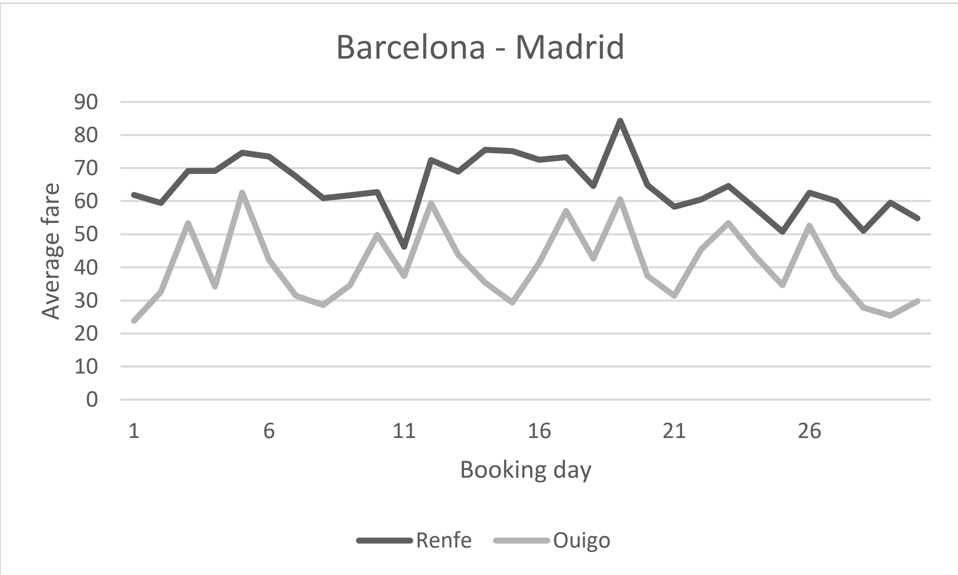

Fig. 4. Temporal profiles of ticket prices on the Barcelona – Madrid route. Source: Analysis of price data from operator's website.

In table 19 the correlation among Renfe and Ouigo fares is shown. In contrast to other countries we do not find a high correlation between the pricing strategies of the competitors.

Table 19. Correlation among Renfe and Ouigo fares on the Barcelona – Madrid route.

Route	Full sample	Booking days		
		1-5	6-15	16-30
Barcelona – Madrid	0.513***	0.834*	0.129	0.752***

*** p<0.01, ** p<0.05, * p<0.1

In table 20 we find the average price differences between Renfe and Ouigo. We see that the average Ouigo price is significantly lower than the Renfe price for all booking periods studies. The difference is quite high in comparison to the other countries we studied. For example, when looking at the full sample we find that the average Ouigo fare is €23.99 lower than the Renfe fare on the same day. This is more than half of the corresponding Ouigo fare.

Table 20. Average price differences between Renfe and Ouigo on the Barcelona – Madrid route. Paired t-test performed on the average price differences between the carriers on the same booking day.

Route Barcelona – Madrid Booking days	Average fare Renfe	Average fare Ouigo	Difference
Full sample	64.616	40.627	-23.990***
	(1.549)	(2.028)	(1.813)
1-5	66.836	41.320	-25.516***
	(2.738)	(7.185)	(5.128)
6-15	66.458	39.200	-27.259***
	(2.841)	(3.089)	(3.918)
16-30	62.649	41.347	-21.302***
	(2.283)	(2.809)	(1.860)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In table 21 we observe the price differences per kilometre among Renfe, entrant Ouigo and the routes that form the control group. We find that both the Renfe and Ouigo ticket prices under open access competition are significantly lower than the prices available on the control routes without open access competition. In line with table 20 we find that the Ouigo fares have a higher difference to the control fares compared to the Renfe fares.

Table 21. Average price differences per kilometre among Renfe, Ouigo and the control fare. Paired t-test performed on the average price differences between Renfe and the control fare and between Ouigo and the control fare.

Booking days	Avg. Fare Renfe	Avg. fare Ouigo	Control fare	Difference Renfe and control fare	Difference Ouigo and control fare
Full sample	0.1039	0.0653	0.1219	-0.0180***	-0.0566***
	(0.0025)	(0.0033)	(0.0024)	(0.0029)	(0.0037)
1-5	0.1075	0.0664	0.1427	-0.0352***	-0.0762***
	(0.0044)	(0.0116)	(0.0036)	(0.0073)	(0.0144)
6-15	0.1068	0.0630	0.1213	-0.0145**	-0.0583***
	(0.0046)	(0.0050)	(0.0030)	(0.0054)	(0.0045)
16-30	0.1007	0.0665	0.1154	-0.0146***	-0.0489***
	(0.0037)	(0.0045)	(0.0024)	(0.0029)	(0.0038)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.1.5. Sweden

In Sweden open access competition takes place on the Stockholm Göteborg route. Here incumbent SJ competes with entrant MTR, which entered the market in 2015. In table 22 we find the context of the Swedish open access competition in the passenger railway market.

Table 22. Context of rail services under open access competition in Sweden.

Route	Distance (km)	Carrier	Time (h)	Daily services	Market share
Stockholm - Göteborg	470	SJ	3.05-3.20	11	0.647
		MTR	3.17-3.33	6	0.414

In table 23 we find the descriptive statistics of the SJ and MTR ticket prices on the Stockholm – Göteborg route. In contrast to the other countries we studied, the average ticket price of incumbent SJ is lower than the average ticket price of entrant MTR, namely €66.72 and €71.77 respectively.

Table 23. Descriptive statistics of the SJ and MTR fares on the Stockholm - Göteborg route.

Route	Carrier	Mean	Std. Dev.	Min.	Max
Stockholm - Göteborg	SJ	66.717	31.696	49.302	82.071
	MTR	71.766	39.683	54.390	84.975

In figure 5 we find the temporal profiles of the ticket prices on the Stockholm – Göteborg route. We observe a sharp increase in ticket prices when departure is closer to the booking day.

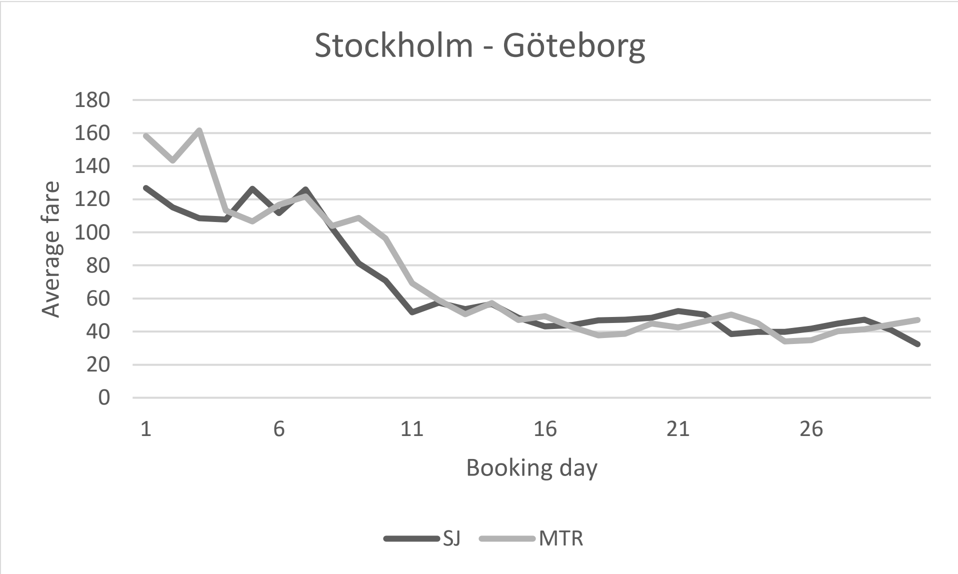

Fig. 5. Temporal profiles of ticket prices on the Stockholm – Göteborg route. Source: Author's analysis of price data from operator's website.

In table 24 we see the correlation among the SJ and MTR ticket prices. For the whole sample we find a correlation of 0.93. However, when looking at other booking horizons the results vary.

Table 24. Correlation among SJ and MTR fares on the Stockholm – Göteborg route.

		Booking days		
Route	Full sample	1-5	6-15	16-30
Stockholm – Göteborg	0.931***	-0.083	0.914***	-0.176

*** p<0.01, ** p<0.05, * p<0.1

In table 25 we find the average price differences between the fares of SJ and MTR. When looking at the full sample we see that the average ticket price of MTR is €5.05 higher compared to SJ. For the booking period of 1 to 5 days before departure this difference increases to €19.75. Looking at the booking period of 16 to 30 days ahead of departure we do not find a significant difference between the fares of both competitors.

Table 25. Average price differences between SJ and MTR on the Stockholm - Göteborg route. Paired t-test performed on the average price differences between the carriers on the same booking day.

Route Stockholm - Göteborg Booking days	Average fare SJ	Average fare MTR	Difference
Full sample	66.717	71.766	5.050**
	(5.787)	(7.245)	(2.817)
1-5	116.888	136.637	19.748*
	(4.166)	(11.379)	(12.436)
6-15	76.001	83.053	7.052**
	(8.877)	(9.243)	(3.776)
16-30	43.803	42.618	-1.185
	(1.330)	(1.254)	(1.982)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In table 26 we test whether the average prices of SJ and MTR under open access competition differ from SJ's prices without competition. We obtain various, thus, inconsistent results. For example, we see that the SJ fare under competition is significantly €0.012 lower than the SJ fare on routes without competition. Instead, when looking at the full sample we do not find a significant difference between the MTR fare under direct competition and the SJ control fare without competition. Interestingly, shortly before departure we find both SJ and MTR fares under competition to be higher than the SJ fares without competition. This may be explained by the fact that train capacity between Stockholm and Göteborg is scarce, which allows operators to raise their prices.

Table 26. Average price differences per kilometre among SJ, MTR and the control fare. Paired t-test performed on the average price differences between SJ and the control fare and between MTR and the control fare.

Booking days	Avg. Fare SJ	Avg. fare MTR	Control fare	Difference SJ and control fare	Difference MTR and control fare
Full sample	0.1420	0.1527	0.1538	-0.0119**	-0.0011
	(0.0123)	(0.0154)	(0.0084)	(0.0060)	(0.0079)
1-5	0.2487	0.2907	0.2265	0.0222*	0.0642**
	(0.0089)	(0.0242)	(0.0131)	(0.0140)	(0.0195)
6-15	0.1617	0.1767	0.1702	-0.0085	0.0065
	(0.0189)	(0.0197)	(0.0086)	(0.0125)	(0.0116)
16-30	0.0932	0.0907	0.1187	-0.0255***	-0.0280***
	(0.0029)	(0.0027)	(0.0039)	(0.0049)	(0.0122)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.1.6. Concluding comments

We observe different pricing strategies among the five countries studied. In Austria and Spain we find a mediate relationship between the pricing strategies of the incumbent and the entrant, while we find a high correlation between the fares of the incumbent and entrant in CZ, Italy and Sweden. This is consistent with earlier research that the incumbent and entrant adopt their pricing behaviour under direct competition. In many cases we find scarcity in train capacity which enables operators to raise prices shortly ahead of departure. Price competition is stronger when booking more days ahear of departure.

In addition, in Austria, CZ, Italy and Spain we observe that the entrant offers lower fares on average compared to the incumbent. This is consistent with literature about price wars between incumbent and entrant and the absence of sustainable profitability. We do not find support for this observation in Sweden. Indeed, we there find evidence that the entrant is more expensive than the incumbent.

Last, we observe variations between countries in the differences between incumbent, entrant and control prices per kilometre. In CZ, Italy and Spain, both the incumbent and entrant have on average lower prices on routes with open access competition compared to routes with a practical monopoly without competition. In Sweden we find no clear evidence for a significant effect of open access competition on ticket prices. v In Austria we find no evidence that the incumbent charges lower prices on its route under open competition than on its routes without direct competition. However, the entrant offers lower fares in comparison with the incumbent's routes without competition. Thus, on the route under open access on average lower ticket prices are available due to the presence of the entrant than on routes without competition.

5.2. Aggregate ticket price analysis

In this section we answer the main research question. We quantify the aggregate effect of open access competition on rail ticket prices. We first investigate whether there exists a relationship between pricing strategies of incumbents and entrants in general. Next, we analyse whether the entrant's ticket prices are lower on average compared to the incumbent. We also look if the ticket prices per kilometre of the incumbent and entrant are lower than the control price. Last, we stop distinguishing between the incumbent and the entrant. We aggregate all data to test whether ticket prices under open access competition are lower compared to prices without open access competition.

The relationship among the ticket prices of incumbent operators and entrant operators is shown in table 27. We find a significant correlation of 0.89 for all periods studied of all routes. This means that ticket prices among competitors tend to develop in the same direction. This finding supports existing literature on the presence of strategic pricing behaviour between carriers operating under direct open access competition.

Table 27. Correlation among incumbent and entrant fares on all routes analysed.

		Booking days		
Routes	Full sample	1-5	6-15	16-30
Wien – Salzburg Praha – Ostrava Milano – Roma Barcelona – Madrid Stockholm – Göteborg	0.892***	0.885***	0.890***	0.892***

*** p<0.01, ** p<0.05, * p<0.1

Next, we look at the average price differences per kilometre between incumbents and entrants. The results are shown in table 28. We find that average ticket prices of the entrant operators are significantly lower compared to the incumbents for all periods studies. For all booking periods, the difference is quite similar. For the full sample, for example, the average ticket price per kilometre of entrants is €0.018 lower compared to the price of the incumbents. This makes up approximately 20% of the total fare per kilometre.

Table 28. Average price differences per kilometre between incumbents and entrants on all routes analysed. Paired t-test performed on the average price differences among the incumbents and entrants on the same booking day.

Booking days	Average fare incumbents	Average fare entrants	Difference
Full sample	0.1062	0.0882	-0.0180***
	(0.0043)	(0.0048)	(0.0022)
1-5	0.1401	0.1197	-0.0203**
	(0.0152)	(0.0194)	(0.0092)
6-15	0.1115	0.0933	-0.0182***
	(0.0072)	(0.0083)	(0.0038)
16-30	0.0915	0.0744	-0.0171***
	(0.0042)	(0.0039)	(0.0019)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In table 29 we find the average price difference among the incumbent, entrants and the control fare. Under open access competition we find both the average prices of the incumbents and entrants to be significantly lower than the average price on the control routes without open access competition. For example, when looking at the full sample the average fare of the incumbents is €0.011 lower compared to the control fare without competition. For the full sample we also find that the average price of the entrants is €0.029 lower compared to the control price.

Table 29. Average price differences per kilometre among incumbents, entrants and the control fare. Paired t-test performed on the average price differences between incumbents and the control fare and between entrants and the control fare.

Booking days	Avg. fare incumbents	Avg. fare entrants	Control fare	Dif. incumbents and control fare	Dif. entrants and control fare
Full sample	0.1062	0.0882	0.1170	-0.0108***	-0.0288***
	(0.0043)	(0.0048)	(0.0044)	(0.0019)	(0.0029)
1-5	0.1401	0.1197	0.1586	-0.0185**	-0.0388***
	(0.0152)	(0.0194)	(0.0160)	(0.0074)	(0.0140)
6-15	0.1115	0.0933	0.1193	-0.0079***	-0.0261***
	(0.0072)	(0.0083)	(0.0069)	(0.0032)	(0.0043)
16-30	0.0915	0.0744	0.1016	-0.0101***	-0.0273***
	(0.0042)	(0.0039)	(0.0043)	(0.0019)	(0.0020)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In this section, we do not distinguish between incumbents and operators. We compare the average ticket price on routes under open access competition with the average ticket price on routes without open access competition. The results are shown in table 30. We find in our dataset that the average fare with open access competition is significantly lower than the average fare without open access competition. For the full sample this difference is €0.020. When booking 1 to 5 days, 6 to 15 days and 16 to 30 days ahead of departure the differences are €0.029, €0.017 and €0.019 respectively.

Table 30. Average price differences per kilometre between routes under open access competition and control routes without open access competition. Paired t-test performed on the average price differences among the routes with and without open access competition on the same booking day.

All routes Booking days	Average fare with open access competition	Average fare without open access competition	Difference
Full sample	0.0972	0.1170	-0.0198***
	(0.0033)	(0.0031)	(0.0018)
1-5	0.1299	0.1586	-0.0287***
	(0.0123)	(0.0112)	(0.0080)
6-15	0.1024	0.1194	-0.0170***
	(0.0056)	(0.0049)	(0.0028)
16-30	0.0829	0.1016	-0.0187***
	(0.0029)	(0.0030)	(0.0015)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.2.1. Concluding comments

To summarise, in our dataset we find a significant correlation among the ticket prices of the incumbents and entrants. This indicates that competitors react to pricing behaviour of the other carrier operating on the same route for the same passengers at the same time by altering their prices in the same direction as their opponent. We also observe that the average ticket price of the entrant is lower compared to the incumbent. Moreover, both the incumbent's and entrant's ticket prices under open access competition are lower than comparable ticket prices on routes without open access competition. This claim also holds when not distinguishing between incumbents and entrants; average ticket prices on routes with open access competition are lower than average ticket prices on routes without open access competition.

5.3. The effect of open access competition on ticket prices

In this section we answer our main research question and quantify the effect of open access competition in the long distance passenger railway market on rail ticket prices. We run a lineair-log OLS regression with the log of the average ticket price as dependent variable. Our independent variables are the presence of open access competition and the booking day ahead of departure. Our control variables are the GDP per capita and the number of the population. The results of our regression are shown in table 31.

In model 1 we do not control for our control variables GDP per capita and the number of the population. The variables open access competition and booking day are significant, while booking day squared is not significant.

In model 2 we control for the variables GDP per capita and the number of population. The variable open access competition is negative and highly significant. We find that in the presence of open access competition the average ticket price is 22.8% lower compared to the situation without open access competition. Therefore, the empirical evidence is in favour of the presence of open access competition exerting a downward pressure on rail ticket prices. The variable booking day is negative and highly significant and the variable booking day squared is positive and significant. This means that the negative effect of the booking day on the average ticket price is diminishing with each extra booking day ahead of departure. Therefore, we find that the average ticket price decreases if the booking day is further ahead of departure until the turning point is reached. Our calculations show that the ticket price decreases in the booking period from 1 day to 63 days ahead of departure. Booking further ahead of departure ticket prices stop decreasing and may even increase slightly.

Table 31. Regression results with as dependent variable the log of the average ticket price.

VARIABLES	(1) Model 1	(2) Model 2
Open access competition	-0.228***	-0.228***
	(0.0540)	(0.0360)
Booking day	-0.0293**	-0.0293***
	(0.0122)	(0.00811)
Booking day^2	0.000464	0.000464*
	(0.000381)	(0.000254)
GDP per capita		4.02e-05***
		(1.94e-06)
Population		0.000238***
		(1.31e-05)
Constant	-1.955***	-3.961***
	(0.0894)	(0.104)
Observations	450	450
R-squared	0.092	0.598

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.3.1. Concluding comments

Thus, we find that the presence of open access competition results in lower ticket prices compared to the situation without open access competition. We also find that the ticket price decreases when the booking day is further ahead of departure. This negative price effect is diminishing when booking further ahead of departure until a turning point is reached.

6. Conclusion and discussion

In this paper we answer the question on the effect of open access competition in the long distance passenger rail market on rail ticket prices. Thus, our research focusses on intramodal competition. To address this question, we first looked at the effects of open access competition on ticket prices in the countries in our dataset, which are Austria, CZ, Italy, Spain and Sweden. Afterwards, we aggregated all data to measure the overall effect of open access competition in the long distance passenger rail market on rail ticket prices. On country and aggregated level, we studied the pricing behaviour of incumbent operators and entrant operators under open access competition. Moreover, we looked at the difference between ticket prices of incumbent operators and entrant operators on routes where they operate under open access competition. Next, we discussed whether average ticket prices on routes with open access competition are lower compared to routes without open access competition. Last, we ran an OLS regression to measure the effect of open access competition and the booking day on the ticket price.

Our results show that the pricing behaviour strategy of the competing operators differ among the five countries we studies. In CZ, Italy and Sweden we find a high correlation between the ticket prices of the incumbent operators and entrant operators, which supports the existence of a relationship in reactional pricing behaviour among competing carriers. In Austria and Spain we find support for this relation as well, but the correlation is less high.

The findings of our research also present that in Austria, CZ, Italy and Spain the entrant operator has lower average ticket prices than the incumbent operator. We do not find support for this claim in Sweden. In addition, in CZ, Italy and Spain both the incumbent and entrant have on average lower prices on routes with open access competition compared to routes without open access competition. In Austria, the incumbent carrier does not offer lower prices under open access competition compared to the situation without open access competition. The entrant does offer lower prices compared to the situation with no competition indeed. In Sweden we find no evidence for an effect of open access competition on ticket prices. Thus, according to our results it is hard to draw overall conclusions on the effect of open access competition on ticket prices based on a single example as the results differ per country. This implies that overall research is necessary for good policy interventions on open access competition in the long distance passenger rail market as we have done in this paper.

Based on data from all countries with large scale open access competition in the long distance passenger rail market, we find a significant correlation among the ticket prices of the incumbent operators and entrant operators. This indicates that there exists a relationship among the pricing behaviour among competitors and that these competitors adopted a reactional pricing strategy to their opponent. We also find that the ticket price of entrant operators is lower compared to incumbent operators. In addition, ticket prices of both incumbents and entrants are lower in situations with open access competition compared to situations without open access competition. This claim also holds when not distinguishing between incumbents and entrants; ticket prices on routes with open access competition are lower than average ticket prices on routes without open access competition.

Our results show that the presence of open access competition in the long distance passenger rail market results in 22.8% lower rail ticket prices compared to the situation without open access competition. We also find that the ticket price decreased when the booking day is further ahead of departure. This negative price effect is diminishing when booking further ahead of departure. The turning point is reached when booking 63 days ahead of departure. Booking more than 63 days ahead of departure will not result in a further price decrease.

We have some recommendations for further research. Our research is based on an extensive, self-created dataset. However, this dataset is limited as it is collected at one time stamp and does not include temporal data. The absence of extensive data on ticket prices and train supply in the rail passenger market has a negative effect on the quantity and quality of research performed in this sector and, thus, on policy interventions. Data on ticket prices and train supply should be collected and published as is done in the airline industry. Moreover, our data may be slightly impacted by the Covid-19 pandemic. At the time of obtaining the data most trains were running according their normal schedule and capacity. However, small alterations and biases in the data are possible due to Covid-19 restrictions in the countries that we studied. For verification of our results this research could be repeated after the pandemic is finished. Last, an important aspect which needs attention is the absence of sustainable profitability in long distance passenger rail markets under open access competition due to price wars among competing operators. In the short term ticket prices decrease under open access competition. However, on the long term unprofitable operations could result in market exits, a practical monopoly and price increases. Research and improved regulation is needed on the profitability of passenger rail services under open access competition.

7. References

Alexandersson, G. (2009). Rail privatization and competitive tendering in Europe. *Built Environment*, 35(1), 43-58.

Antes, J., Friebel, G., Niffka, M., & Rompf, D. (2004). Entry of low-cost airlines in Germany: some lessons for the economics of railroads and intermodal competition. *Northwestern University, Evanston*, IL.

Behrens, C., & Pels, E. (2012). Intermodal competition in the London–Paris passenger market: High-Speed Rail and air transport. *Journal of Urban Economics*, 71(3), 278-288.

Bergantino, A. S., & Capozza, C. (2015). One price for all? Price discrimination and market captivity: Evidence from the Italian city-pair markets. Transportation Research Part A: Policy and Practice, 75, 231-244.

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.

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(1), 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.

Cascetta, E., & Coppola, P. (2014). Competition on fast track: an analysis of the first competitive market for HSR services. *Procedia-Social and Behavioral Sciences*, 111, 176-185.

Casullo, L. (2016). The Efficiency Impact of Open Access Competition in Rail Markets. The Case of Domestic Passenger Services in Europe. *International Transport Forum OECD.* Retrieved from: https://www.itf-oecd.org/sites/default/files/docs/dp201607.pdf

CNMC. (2019). Acuerdo por el que se emite informe relativo a las propuestas de ADIF y ADIF Alta Velocidad sobre la modificación de la deleración sobre la red de 2019. Retrieved from: https://www.cnmc.es/sites/default/files/2541816_2.pdf

Delaplace, M., & Dobruszkes, F. (2015). From low-cost airlines to low-cost high-speed rail? The French case. *Transport policy*, 38, 73-85.

Deville, X., & Verduyn, F. (2012). Implementation of EU legislation on rail liberalisation in Belgium, France, Germany and The Netherlands (No. 221). *NBB Working Paper*.

European Commission. (2021). Railway packages. Retrieved from: https://ec.europa.eu/transport/modes/rail/packages_en

Feuerstein, L., Busacker, T., & Xu, J. (2018). Factors influencing open access competition in the European long-distance passenger rail transport—A Delphi study. *Research in Transportation Economics*, 69, 300-309.

Fröidh, O., & Byström, C. (2013). Competition on the tracks–Passengers' response to deregulation of interregional rail services. *Transportation Research part A: policy and practice*, 56, 1-10.

Givoni, M., & Banister, D. (2006). Airline and railway integration. *Transport policy*, 13(5), 386-397.

Gleave, S. D. (2006). Air and rail competition and complementarity. *Case study report prepared for European Commission DG Energy and Transport*, 1-149.

Gleave, S. D. (2015). Study on the Cost and Contribution of the Rail Sector. *European Commission Directorate General for Mobility and Transport*. Retrieved from: https://ec.europa.eu/transport/sites/default/files/modes/rail/studies/doc/2015-09-study-on-the-cost-and-contribution-of-the-rail-sector.pdf

Gonzales-Savignat, M. (2004). Competition in air transport: The case of the high speed. *Journal of Transport Economic and Policy*, 38, 77-108.

Ivaldi, M., & Vibes, C. (2005). Intermodal and intramodal competition in passenger rail transport.

Jones, I. (2000). The evolution of policy towards on-rail competition in Great Britain. *Journal of Transport Economics and Policy,* 371-384.

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, 100143.

Martín, J. C., & Nombela, G. (2007). Microeconomic impacts of investments in high speed trains in Spain. *The Annals of Regional Science*, 41(3), 715-733.

Milan, J. (1993). A model of competition between high speed rail and air transport. *Transportation planning and technology*, 17(1), 1-23.

MuConsult. (2017). Sturing overheid bij vervoersconcessies op het spoor. *Rijksoverheid*. Retrieved from: https://rijksoverheid.nl/documenten/rapporten/2017/04/07/deelonderzoek-muconsult-sturing-overheid-bij-vervoersconcessies-op-het-spoor

Séguret, S. (2009). Is competition on track a real alternative to competitive tendering in the railway industry? Evidence from Germany.

Tomeš, Z., Kvizda, M., Jandová, M., & Rederer, V. (2016). Open access passenger rail competition in the Czech Republic. *Transport policy*, 47, 203-211.

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.