1 **Competition in long distance transport: Impacts on prices, frequencies, and**
2 **demand in the Czech Republic**

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Abstract

This article analyses the effect of different entry regulations on company conduct and traveller behaviour. The paper presents a comprehensive case study of three railway markets with significantly different entry policies using data on prices and frequencies together with a survey conducted to obtain revealed preferences. The study employs data from the three main lines in the Czech Republic. The two open access markets tended to provide significantly higher connection frequencies than the line with regulated entry did. Surprisingly, low price variation across the rail and bus markets suggests low monopoly power for the monopolised incumbent and its uniform price strategy across markets with different entry regulations. On the other hand, high price sensitivity among travellers confirms the importance of intramodal competition.

1 Introduction

Open access competition on railways is gradually becoming more widespread, especially after the Fourth Railway Package of the European railway reforms (European Commission, 2016), mostly in Central Europe. The market structure is slowly changing as is passenger behaviour. This ongoing process of deregulation and market restructuring offers a unique opportunity to compare markets with different levels of transformation. The general effect of competition entry on price level, quality of provided services, and frequency is unquestionable.

However, the railway industry has several specifics. Therefore, it is necessary to be careful about the impacts of competitors on the market and demand. First, both intramodal and intermodal competition play an important role in transport behaviour. Therefore, regulated entry in the case of one transportation mode can be partially offset by deregulation in other transport modes. This is often the case for intercity bus and railroad competition. Furthermore, vertical integration of railways, together with high fixed costs, can make entries socially undesirable. Finally, from the traveller's perspective, rail services will always remain heterogeneous due to such factors as the importance of departure times. Therefore, some non-zero market power always exists and may be challenging to regulate, if desired. For these reasons and some additional issues, open access for railroads remains the subject of ongoing discussion.

The aim of this paper is to analyse the effects of different types of railway competition on both firms' conduct and travellers' behaviour using price and frequency information together with elasticity analysis.

66 The Czech transportation market provides a unique opportunity for cross-section comparison
67 due to the variability of competition across different lines. The markets to compare include the
68 following long-distance transport routes: Prague–Brno, Prague–Ostrava, and Brno–Ostrava.
69 The Prague–Ostrava market has been a competitive open-access line since 2011 with the un-
70 precedented competition of three train providers (Czech Railways, RegioJet since 2011, and
71 LeoExpress since 2013). The Prague–Brno market has represented a mixed market since 2016
72 with both the incumbent providing public service obligation (PSO) services and open access
73 competitor RegioJet operating at its own risk (and also providing bus services via the parallel
74 D1 motorway in competition mainly with FlixBus). Thus, this route is a case of intense inter-
75 modal coach and rail competition. The last relevant route, Brno–Ostrava, was operated as a
76 PSO by a state-owned company (Czech Railways). In December 2019, however, the incumbent
77 Czech Railways was replaced on the Brno–Ostrava line by RegioJet for the first time in history.
78 This change is unfortunately not captured in our data. Nevertheless, individual transportation
79 remains the only relevant alternative to the train on this route. Therefore, one needs to be careful
80 in any direct comparison of these routes as it lacks public alternatives[1]. Moreover, this is the
81 only route in our analysis that is not connecting a city with the capital. This can have some
82 important implications for demand.

83 Regarding individual transportation, the Prague–Ostrava line has a very similar situation as
84 there is no direct motorway connecting the two cities. The competitive intermodal route from
85 Prague to Brno includes a relevant car alternative. According to our survey, however, 92% of
86 both car drivers and their passengers do not use any other transport alternative on these routes.
87 These travellers are thus the least flexible out of all relevant transport modes. Therefore, we
88 included only public transport in our further analysis

89 Table 1 summarises the main attributes of each transport market.

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[1] There are some bus services on the Brno–Ostrava line, but they usually have many more stops and a much longer travel time compared to the train (more than 3 hours by bus compared to a little more than 2 hours by train). According to our preliminary research based on focus groups, there are very few people using this mode of transport on this line. Buses are used only for travelling shorter sections, such as to Olomouc.

90 Table 1 Markets and competition

	Open access	PSO/incumbent	Intramodal competition	Intermodal competition
Prague–Brno	Yes (since 2016)	Yes	Yes	Yes
Prague–Ostrava	Yes (since 2011)	No	Yes	No
Brno–Ostrava	No	Yes	No	No[2]

91 We utilised data on prices and frequencies from publicly available timetables and revealed pref-
92 erences obtained from a survey to compare markets with different entry setups and structures.
93 The case study analyses the three main lines in the Czech Republic with different regulatory
94 frameworks. The lines comprise: a monopolised market, a fully open access with three railway
95 competitors, and a mixed market including the incumbent contracted as a PSO and an entrant
96 in business at its own risk. This last market is well-known for its tough intramodal as well as
97 intermodal competition.

98 The rest of the paper is structured in the following way. First, we present a review of the liter-
99 ature on open-access entries and their effects on competition and travel behaviour. Then, we
100 clarify the research question and explain the methodology. Descriptive statistics of the con-
101 sumer survey follow. After that, we present elasticity estimations as a complementary analysis.
102 Finally, we discuss the results, list the research implications, and provide conclusions.

103 2 Literature review

104 Open-access competition on railways means a situation where the market is open, new entrants
105 can enter it, and operations are not subsidised from public resources. Experience with open-
106 access competition in passenger railway transport is quite limited – only a few countries have
107 experienced this type of competition. Head-on entries on principal railway routes can be found
108 only in Austria, the Czech Republic, Italy, Slovakia, and Sweden. Several case studies have
109 analysed free entries on railroads and their effect on the given market. Almost all of these stud-
110 ies have confirmed a positive effect from competition on prices – Cascetta & Coppola (2013),
111 Bergantino et al. (2015), Beria et al. (2016), and Desmaris & Croccolo (2018) for Italy; Tomeš
112 et al. (2016) for the Czech Republic; Kvizda & Solnička (2019) for Slovakia; Tomeš & Jandová
113 (2018) for the Czech Republic, Slovakia, and Austria; and Vigren (2017) for Sweden. Higher
114 service quality and product differentiation are among the other positive effects from competi-
115 tion as documented in all of the aforementioned studies. However, competition is not the only
116 factor determining prices, but also demand, capacity or willingness to pay (Beria & Bertolin,

[2] As already mentioned, the relevance of intermodal competition is low.

117 2019). Competition also contributed to increased ridership (Fröidh & Nelldal, 2015). Accusa-
118 tions of unfair practices were not rare: price war in the Czech Republic (Tomeš et al., 2016),
119 Slovakia (Kvizda & Solnička, 2019), and Austria (Tomeš & Jandová, 2018) or political action
120 in Poland (Król et al., 2018). On the other hand, Bergantino et al. (2015) do not find evidence
121 of predatory pricing by the incumbent, and Desmaris & Croccolo (2018) show that there is no
122 blatant evidence of anti-competitive behaviour against the new operator in Italy. However,
123 lower prices meant slowly growing revenues, which has caused problems with long-term prof-
124 itability. Pressure on infrastructure capacity and the coexistence of open access and PSOs are
125 other significant problems (Tomeš & Jandová, 2018), especially in the Czech Republic.

126 The findings of these case studies are in line with the modelled situation for a duopoly market
127 in Broman & Eliasson, 2019. These authors found equilibrium with one dominant firm holding
128 more than two thirds of the market. Such asymmetry stems from natural differentiation of com-
129 panies through the heterogeneity of departure times. However, such an outcome is still prefer-
130 able with respect to overall welfare compared to a profit-maximising monopoly. On the other
131 hand, Wheat et al. (2018) found cost disadvantages for firms operating on open-access markets.
132 This stemmed from both comparable costs for franchised operators and the loss the advantage
133 to profit from increasing returns to scale common to monopolised markets. This was partially
134 confirmed in a market with three competitors as described in Tomeš et al. (2016). All three of
135 the operators remained unprofitable after opening competition on the Czech Prague–Ostrava
136 line.

137 In addition to intramodal (railway) competition, intermodal competition between rail and
138 coaches is also worth investigating, especially due to a parallel highway on the Prague–Brno
139 route in the Czech Republic. Fare (Finez, 2014; Paulley et al., 2006), travel time or speed (Beh-
140 rens & Pels, 2012; Fröidh, 2008), comfort (Fröidh & Byström, 2013, Allard & Moura, 2018),
141 safety (Si et al., 2009), frequency (Raturi & Verma, 2019, Paulley et al., 2006), income (Toro-
142 González, et al., 2020), the opportunity to work (Varghese & Jana, 2018), congestion (Droes &
143 Ritvield, 2015), capacity (Daly et al., 2014), and station availability and parking (Eagling &
144 Ryley, 2015; Pagliara et al., 2012) have been among the most important factors that influence
145 passengers' choices. Yen et al. (2018) mentioned trip characteristics, socio-demographic char-
146 acteristics, frequency, the need for transfers, and easier accessibility. Frequency, transfers, traf-
147 fic congestion, and shortages of parking spaces were discussed by Ben-Akiva & Morikawa
148 (2002). Attitudes and perceptions have also affected the way individuals choose between dif-
149 ferent transport modes, in addition to price and product differentiation (Bahamonde-Birke et
150 al., 2014).

Rail and bus intermodal competition led to price decrease on routes with intermodal competition compared to monopolistic routes (Gremm, 2018). In Aarhaug et al. (2018), competition from low-cost air carriers was significant for long-distance coach lines, whereas improved road infrastructure and rail services led to increased competition from private cars and rail for shorter coach lines. Moreover, Beria et al. (2018) showed that intermodal competition matters with results that bus routes overlapping with rail PSO are priced less, but interestingly this happens also for high-speed lines. This shows that the two markets are not independent. The level of intermodal long-distance passenger competition in France is high among coaches, BlaBlaCar, highspeed rail, and also low-cost airlines (Crozet & Guihéry, 2018). New deregulated bus services represent only about 2% of long-distance transport. However, intramodal competition is very strong. Burgdorf et al. (2018) analyse long-distance bus services in Germany. They show that price, speed, reliability, convenience, and the carriage of luggage are the most important determinants of modal choice.

As it is clear from the rich body of literature, competition in long-distance transport and especially in railway brings some indisputable benefits for passengers and transport system in general. Most of the aforementioned papers analysed the effects using mostly individual case studies of a single route or by analysing partial characteristics of the examined markets.

Our paper contributes to the existing empirical literature on competition and regulatory effects in long-distance passenger transportation by providing a robust analysis of the effects of different regulatory regimes and competition. We collected a vast amount of data with respect to prices, frequencies, and departure times for three different markets with different regulatory regimes to analyse the firm's conducts. Moreover, we carried out two focus groups and additional surveys to understand passenger's behaviour with respect to varying conditions on examined markets. Furthermore, we used signalling data from mobile operators to verify our survey sample composition.

3 Research question, data, and methods

This section presents the research question and a methodology adequate to answer it.

3.1 Research question

The regulatory framework represents an important element in long-distance transport markets. Therefore, the corresponding research question is to determine what effects bring open access in railway compared to more traditional PSO services and how different institutional frameworks influence behaviour of intermodal and intramodal competitors together with travellers

184 on different markets. To answer this question, we carried out a survey to collect data on pas-
185 sengers' mobility choices. In addition, we gathered data on prices and frequencies and then
186 carried out elasticity analysis using discrete choice models.

3.2 Frequency and price data collection

188 The first methodological step was based on frequency and price data collection for the relevant
189 transport markets (the selected three routes) during the same time: from 9 November to 22
190 November 2019. We collected standard ticket purchases without any special tariffs or discounts
191 (from relevant webpages). The data set consists of more than 12,000 bus and train connections
192 and ticket prices on the relevant routes provided by Czech Railways, RegioJet, LeoExpress, and
193 FlixBus.

194 Further, we merged these data with the mobility survey to adjust for possible different impacts
195 from special tariffs (for students, seniors) in comparison with standard tickets. The level of
196 senior and student discounts on public transport tickets is guaranteed at 75% by the Czech Min-
197 istry of Transport (excluding taxis and relatively new car alternatives such as car sharing and
198 carpooling).

199

3.3 Passenger survey data collection

201 As a preliminary launching research step before the mobility survey, we conducted two focus
202 groups for the Prague–Brno transport market. We focused on the modal choice between bus
203 and train, including the respondents' relationships or loyalty to a service provider despite var-
204 ying conditions – price, frequency, age category, and other socio-demographic features. These
205 focus groups brought some preliminary results that helped in designing the main mobility sur-
206 vey.

207 The mobility survey aimed to identify the factors determining the use of a particular transport
208 service by inspecting the preferences of passengers. The results of the survey served as feedback
209 on the opinions, attitudes, and reasons on the basis of which passengers "choose" or "do not
210 choose" a specific mode of transport and a specific company. The survey was carried out via
211 systematic sampling, arranging the study population in accordance with selected routes and
212 modes during October and November 2019. Interviewers carried out the data collection via
213 face-to-face paper and pen interviews localised in trains and buses or at train stations, bus stops,
214 or motorway rest areas. In the case of bus and train passengers, there were two phases of field
215 data collection. In the first phase, the form and content of the questionnaire were verified by a

216 pilot survey of 50 bus and train passengers. In the second phase, the survey was conducted
217 using an optimised questionnaire.

218 In the case of modal choice focused on car passengers, there were also two phases, but with a
219 slightly different design. The data collection was followed by verification with 10% of car re-
220 spondents. Randomly selected respondents were queried through telephone inquiries and e-mail
221 correspondence on the basis of screening questions to select respondents who had been on a car
222 journey on a relevant route (Prague–Brno, Brno–Ostrava, or Prague–Ostrava) within the previ-
223 ous 14 days.

224 Our research comprises data for three train operators and two bus operators. Table 2 summarises
225 the passenger survey data set, including all complete and relevant interviews. The original sam-
226 ple was even larger with 1887 respondents (see Appendix 1), but due to error answers, the final
227 sample includes only 1521 responses; thus, the error rate was less than 20 % of all sample.

228 Table 2 Number of observations for different modes and operators

Mode	Company	Prague–Brno	Prague–Ostrava	Brno–Ostrava
	Czech Railways	238	229	131
Train	RegioJet	166	191	–
	LeoExpress	–	108	–
Bus	RegioJet	172	–	–
	FlixBus	183	–	–
Car	–	–	–	103

229 We also conducted a parallel study complementary to our key research in 2019 (pre-covid pe-
230 riod) in accordance with our long-term research goals, which was aimed at mobile operator´s
231 signalling big data on population mobility derived from SIM card movements (Ficek, 2019).
232 Based on a very different trajectory of road and railway lines among Prague, Brno, and Ostrava
233 we are able to provide quite precise modal share estimates. These results are furthermore sup-
234 ported by other relevant data about train crews (from Czech Railways company), the capacity
235 of buses (the survey described above in chapter 3.3), from transport Census (Ministry of
236 Transport, 2016) and from road cargo line haul toll monitoring (Ministry of Transport, 2019).
237 Our big data estimates show modal and company transport shares strongly in accordance with
238 our survey sample – see Appendix 2. There are more bus companies operating on relevant mar-
239 kets, but RegioJet and Flixbus represent about 84 % of all provided bus capacities.

3.4 Elasticity analysis

241 We used a standardised methodology of discrete choice models with respect to different num-
242 bers of alternatives. All of our models were based on logistic regressions.

243   - Brno–Ostrava (BRQ–OSR): binary logistic regression

244   - Prague–Ostrava (PRG–OSR): McFadden's conditional logistic regression

245   - Prague–Brno (PRG–BRQ): nested multinomial logistic regression

246 The monopolised line Brno–Ostrava had the simplest model. The single alternative train (the
247 choice) was predicted relative to individual car transportation, which was the unchosen alter-
248 native in this case. Therefore, the model is closed in the sense of travelling, and we did not
249 consider outside alternatives, comprising people currently not travelling at all. For an introduc-
250 tion to discrete choice models, see Greene (2009), and for an application, see Tomeš & Fitzová
251 (2019).

252 The Prague–Ostrava market was modelled with McFadden's conditional logistic regression
253 (McFadden, 1973). The three alternatives (trains) compete within the line; therefore, a binary
254 choice is no longer relevant. There are two options to model such a market. The more common
255 option is multinomial logistic regression, which is focused on the individual unit and uses only
256 the individual's characteristics to explain a choice, and the less common is conditional logistic
257 regression (Hoffman & Duncan, 1988). In the second option, there are two forms of independ-
258 ent variables: alternative specific (varying across and within cases, e.g. price) and case-specific
259 (constant within cases, e.g. travel purpose). Our explanatory variables included both types, and
260 so we used the conditional option.

261 The last market, Brno-Prague, is well known for its intense intramodal competition. The well-
262 known problem of the independence of irrelevant alternatives (see McFadden, 1974) can be
263 solved by grouping similar alternatives into groups or nests. In our case, there are two bus
264 alternatives and two train alternatives. This methodological approach was standardised based
265 on the available literature, such as Koppelman & Bhat (2006) and applications in Forinash &
266 Koppelman (1993) and Polydoropoulou & Ben-Akiva (2001).

267 Finally, the elasticities were calculated the same way across different models. First, the original
268 fitted values and adjusted fitted values were calculated. In the case of price elasticities, all ob-
269 servations were adjusted by increasing price and frequency by 1%. The individual elasticity for
270 the given mode and company was then calculated by subtracting the original and adjusted fitted
271 value. The market elasticities for transport mode were calculated as the average across individ-
272 ual elasticities.

4 Exploratory data analysis

274 The following chapter shows the overall context of the passenger long-distance transport mar-
275 ket in the Czech Republic. It provides an exploratory analysis focused on the frequency of con-
276 nections, prices and our survey sample design.

4.1 Long-distance transport markets in the Czech Republic

The research focused on long-distance transport lines connecting three key metropolitan areas (OECD, 2020) – Prague, Brno, and Ostrava. Brno and Ostrava are centres of the Jihomoravský and Moravskoslezský NUTS 3 regions (see Figure 1**Chyba! Nenalezen zdroj odkazů.**), while Prague is a NUTS 3 region itself and also the regional centre for the neighbouring Středočeský region. As we are interested in long-distance travel, we define the entire NUTS3 regions as the relevant area.

Figure 1 Metropolitan population
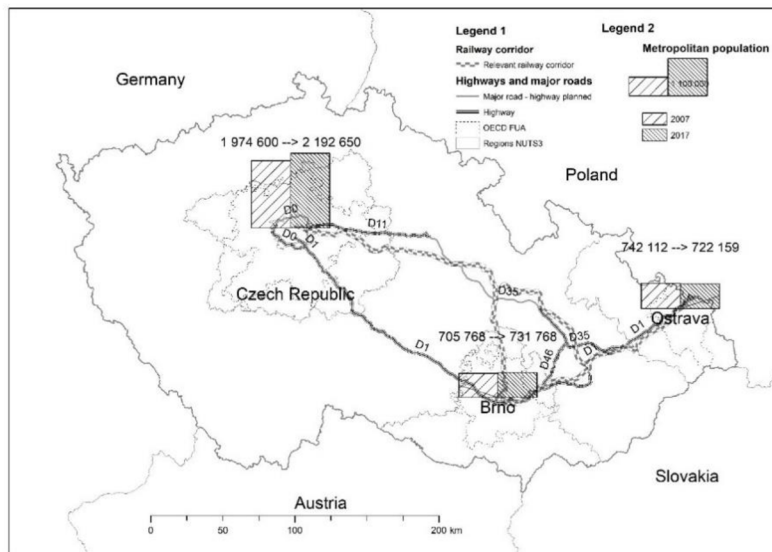
Sources: OECD, 2020; ArcČR ver.3.3, 2020; own processing

Table 3 shows the population, GDP per capita, and the unemployment rate for the metropolitan areas of interest.

Table 3 Metropolitan stats – population density, GDP per capita, and unemployment rate

Relevant NUTS 3 regions	Population density			GDP per capita (EUR)			Unemployment rate		
	2007	2017	change	2007	2017	change	2007	2017	change
Prague and Středočeský	207.06	228.68	+10.4%	580,468	715,428	+23.3%	2.79	3.25	+0.47pp
Jihomoravský	157.82	164.08	+4.0%	337,998	450,135	+33.2%	5.61	5.05	−0.56pp
Moravskoslezský	230.21	222.49	−3.4%	307,168	392,827	+27.9%	7.84	6.42	−1.42pp

Sources: OECD, 2020; Pařil & Viturka, 2020, own processing.

Table 3 shows significant long-term changes in metropolitan structure in the Czech Republic. The metropolization process in Prague and Středočeský region surrounding the Czech capital is obvious regarding increasing population density in these two regions driven by suburbs in Prague´s neighbourhood. Continuing suburbanization and metroplization process occur in Jihomoravský region surrounding Brno. However, in Moravskoslezský region with the capital of

296 Ostrava, the decrease of population density exhibits the long-term depopulation process. Fur-
297 thermore, Prague and its metropolitan area have a significant economic performance with a
298 very low unemployment rate that reflects the hegemon economic position of the Czech capital.

4.2 Connection frequency

300 In addition to prices, the frequency of connections is another essential variable influenced by
301 the level of intramodal and intermodal competition as well as the openness of the railway mar-
302 kets. Table 4 provides the average number of connections per day over a week.

303 Table 4 Connections per day

Mode	Company	Prague–Brno	Prague–Ostrava	Brno–Ostrava
Bus	FlixBus	18		
	RegioJet	22		
Train	Czech Railways	32	18	16
	RegioJet	10	12	
	LeoExpress		7	
Total		82	37	16

304 **Chyba! Nenalezen zdroj odkazů.** shows the saturation of the routes during workdays. Every
305 mark represents departure time of a single connection. The colours distinguish direction within
306 the route. There were clear and significant differences among the markets. On average, there
307 was a train or bus connection every 20 minutes between Brno and Prague and every 32 minutes
308 between Prague and Ostrava but only every 74 minutes between Brno and Ostrava.

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309 Figure 2 Saturation of routes
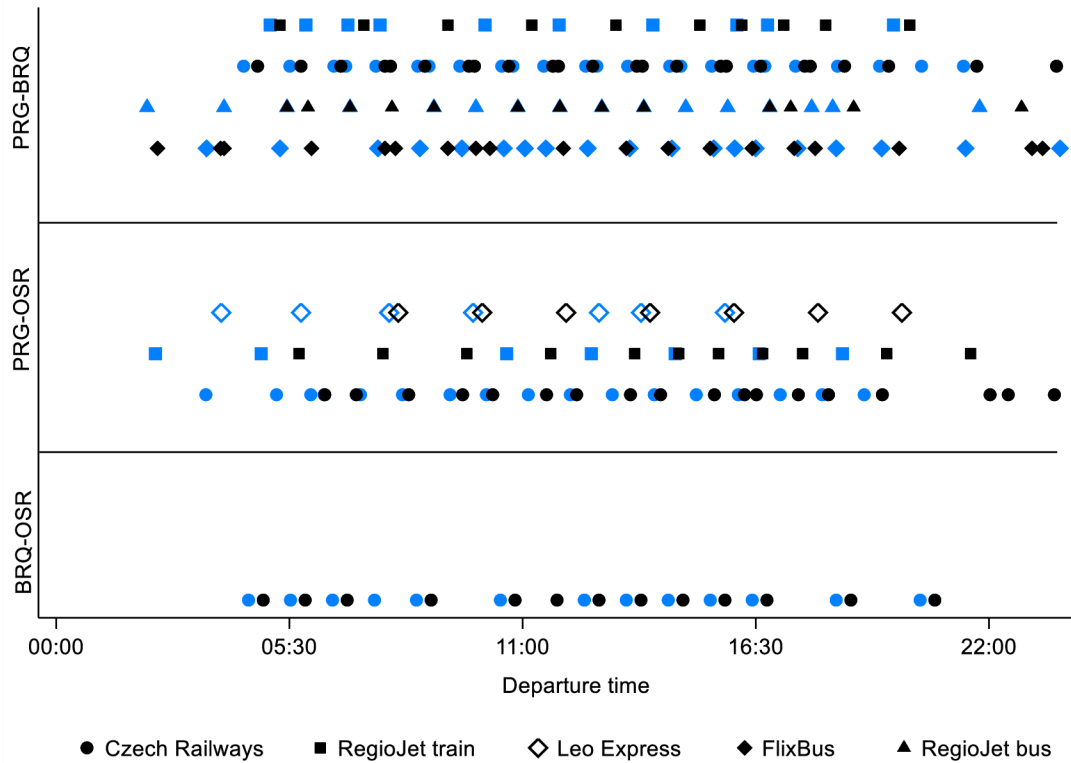
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314 First, observe the frequency on the Prague–Brno line. The number of current connections
315 reaches the limit of the existing capacity for train connections. There are slightly more train
316 connections within the duopoly Prague–Brno market than there are on the Prague–Ostrava route
317 with three competitors. However, the frequencies for Czech Railways on particular markets
318 differed significantly. There were 18 trains on the Prague–Ostrava route, which is very similar
319 to the monopolised market of Brno–Ostrava, but only roughly half of the capacity of the most
320 competitive market, Prague–Brno.

321 In addition to higher peak frequencies, higher off-peak times frequencies are also connected to
322 a higher level of competition. Services on the Brno–Ostrava line were provided only 16 hours
323 per day during the workday compared to more than 21 hours for the other two analysed markets
324 (or 19 hours for the Prague–Brno line excluding bus alternatives).

325 In summary, competition seems to have played an essential role regarding the frequency in both
326 the number of connections and the proportion of the day serviced by public service operators.

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4.3 Pricing strategy assessment

The analysis focused on bus and train tickets provided by the incumbent Czech Railways (CD) and its key competitors RegioJet (RJ), LeoExpress (Leo), and FlixBus (Flix). Figure 3 presents standard ticket pricing box plots for the relevant transport markets, taking into account route, mode, and provider. The lines inside the inner part of the boxes represent the medians, the crosses show the means, and the dots are outliers.

Figure 3 Standard (anytime single) prices (euro cents per km)
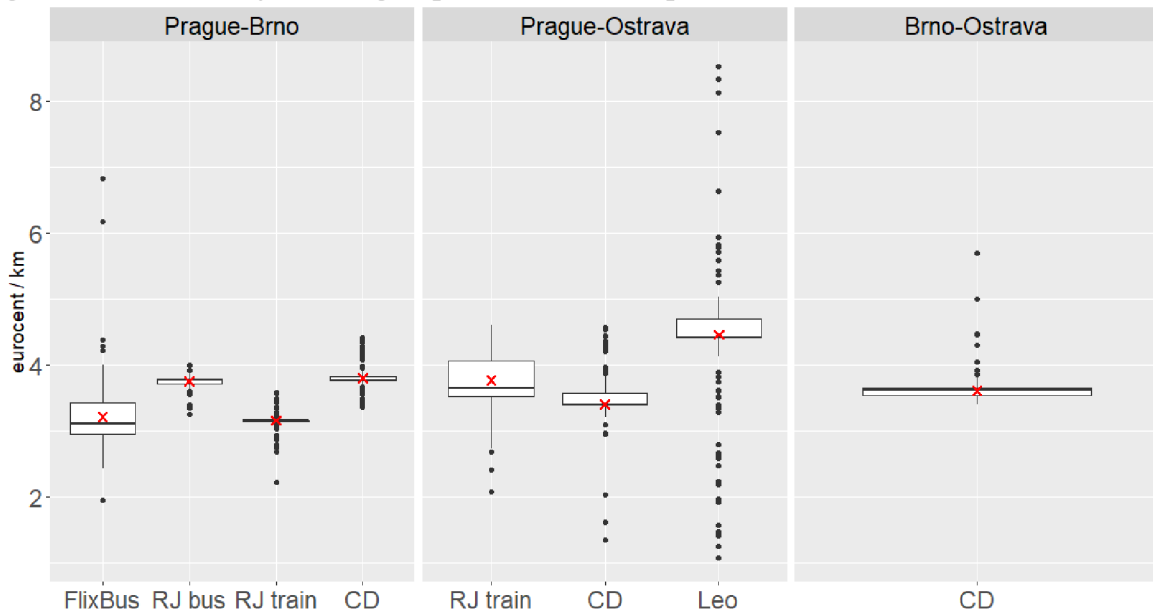
The route from Prague to Ostrava exhibited the greatest price volatility. This is quite an important finding because this passenger transport market is the only fully open train market in the Czech Republic, with three competitors – the incumbent Czech Railways and the two other competitors RegioJet and LeoExpress. The price strategy of LeoExpress was the most flexible. LeoExpress prices varied between 1 and 7 euro cents per km while those of the incumbent and RegioJet were mostly 3.5–4 euro cents per km.

The lowest volatility was observed on the Prague–Brno route for RegioJet buses and trains and also the incumbents' trains, especially when compared to the much more flexible prices of FlixBus.

Figure 4 depicts prices on the relevant transport markets including passenger discounts. These discounts are based primarily on the aforementioned 75% discounts for seniors and students. However, there are many other options provided by particular operators. Czech Railways provided several kinds of loyalty cards: IN25 (25% discounts on each ticket with an initial deposit

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348 of CZK 450/EUR 17 per year),[3] IN50 (50% discounts with an initial deposit of CZK 2,990/EUR

349 112 per year); IN100 (100% discounts with an initial deposit of CZK 19,990/EUR 752 per

350 year); and INbusiness (100% discounts including first-class tickets with an initial deposit of

351 CZK 35,000/EUR 1,316 per year). RegioJet offered credit tickets (with an initial deposit of at

352 least CZK 300/EUR 11 granting discounts on each ticket of around CZK 5/EUR 0.19).

353 Figure 4 Tariff prices including classes and discounts (euro cents per km)
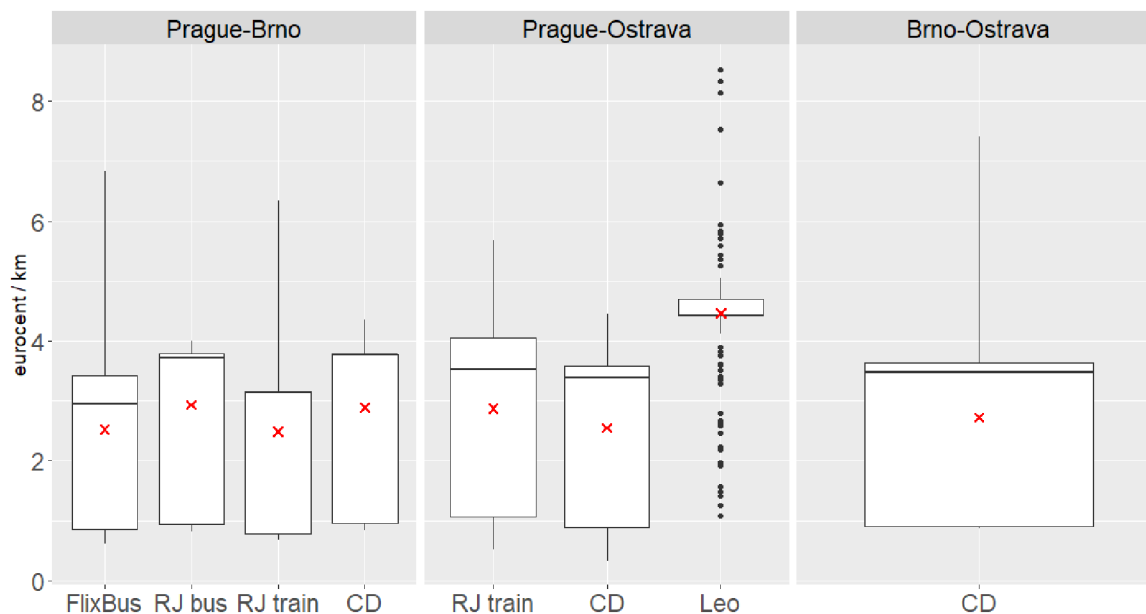
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355 Operators offered different types of services. Czech Railways' fast trains offered second class,

356 first class, and business class. RegioJet offered four types of services: Low cost, Standard, Re-

357 lax, and Business. LeoExpress provided Economy, Business, and Premium tickets (however,

358 premium passengers were very rare as the price was 3 to 5 times as much; therefore, this class

359 was excluded from the sample).

360 The inclusion of tariffs, discounts, and classes had a substantial impact on the minimum prices

361 and the first quartile prices, which were much lower (see Figure 4) than in the previous case.

362 This fact might have been caused by the composition of the population sample (see Figure 7).

363 LeoExpress prices showed the narrowest interquartile range and the highest final ticket price

364 per kilometre bought by passengers (the mean was about 2 euro cents per kilometre higher than

365 those for other modes and providers) as students and seniors represented a minimal share of the

366 passengers. In summary, almost one third of passengers took advantage of 75% discounts. Sim-

367 ilar level of prices has been observed in Slovakia, where seniors and students have been able to

368 travel even with 100% discounts since 2014. Available data from 2018 shows that the share of

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[3] There were also IN cards for 3 months and 3 years.

14

369 100% discount holders including seniors and students on the passenger rail market in Slovakia
370 was more than 37% of all rail passengers in Slovakia (ZSSK, 2019). This fact highlights the
371 important position of senior and student passengers in long-distance domestic public transport.

4.4 Survey passenger characteristics

373 This section describes the main features of the data set regardless of route. First, we analysed
374 the age structure of the travellers, especially the share of students and seniors, which is im-
375 portant due to the 75% discount for these groups. Adult travellers formed 67% of the sample,
376 students 25%, and seniors 8%. However, there were significant differences among the operators
377 – RegioJet attracted significantly more students (31%). The average and median ages were 38
378 and the inner 50% of the travellers were between 26 and 50 years old. Trains were the most
379 common means of transport for seniors, and slightly less so for adults and students.

380 Figure 5 depicts the frequency of travelling for different modes and operators. Most passengers
381 did not travel multiple times per week. Most of the travellers travelled 1–3 times per month or
382 less. The structure of the frequency was similar across various modes and operators. However,
383 occasional travellers (once per year) chose private operators (RegioJet, LeoExpress) more fre-
384 quently than the incumbent, which had the highest share of regular travellers.

385 Figure 5 Passengers' frequency of travelling
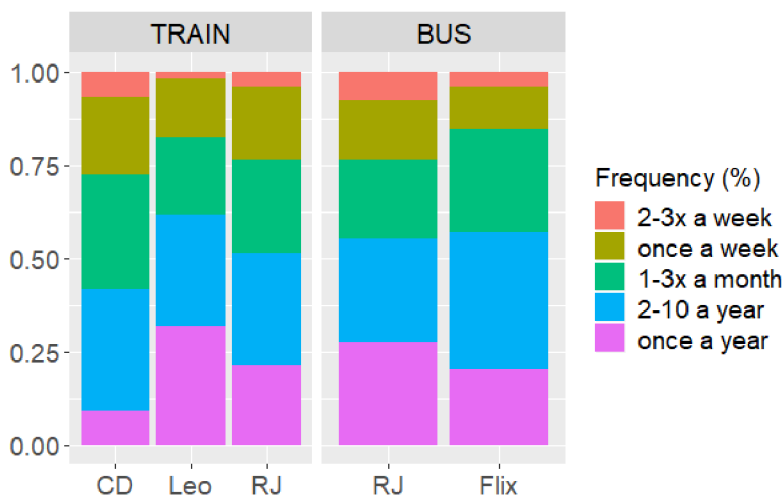
386 Figure 6 shows the types of tickets bought. Most passengers used economy class (Economy or
387 Standard in RegioJet and Economy in LeoExpress). The share of economy tickets was highest
388 for the incumbent. RegioJet provided two types of higher comfort tickets (Relax and Business).

389   Figure 6 Train ticket types
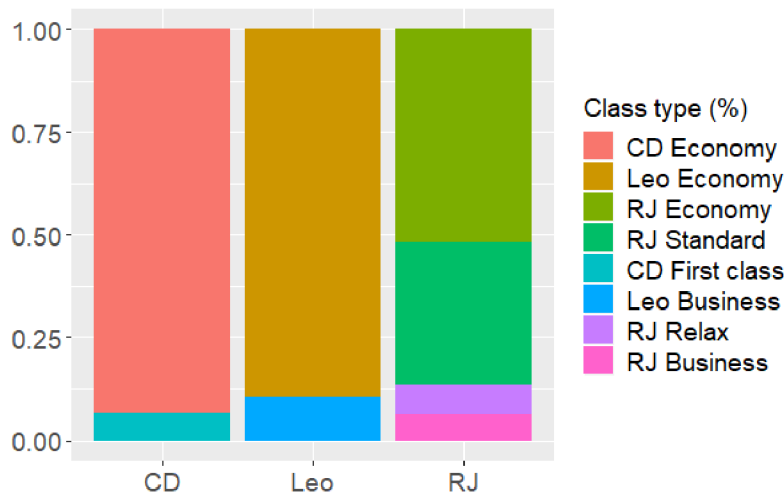
390   Furthermore, about 24% of Czech Railways travellers used an IN card, which enabled users to
391   buy tickets at a discount (e.g. a yearly IN25 card provides a discount of 25% for CZK 450 per
392   year). Similarly, 23% of RegioJet passengers used RegioJet credit tickets, which also enabled
393   buying cheaper tickets but was free of charge.

394   Figure 7 shows the type of economic activity the passengers of the various transport modes and
395   operators were engaged in. Employees (51%) and businessmen (12%) formed the largest part
396   of the travellers, but their proportions were slightly different for the various modes and opera-
397   tors. Businessmen represented 25% of all LeoExpress passengers. Students represent another
398   large group (24%); they substantially preferred RegioJet.

399   Figure 7 Economic activity
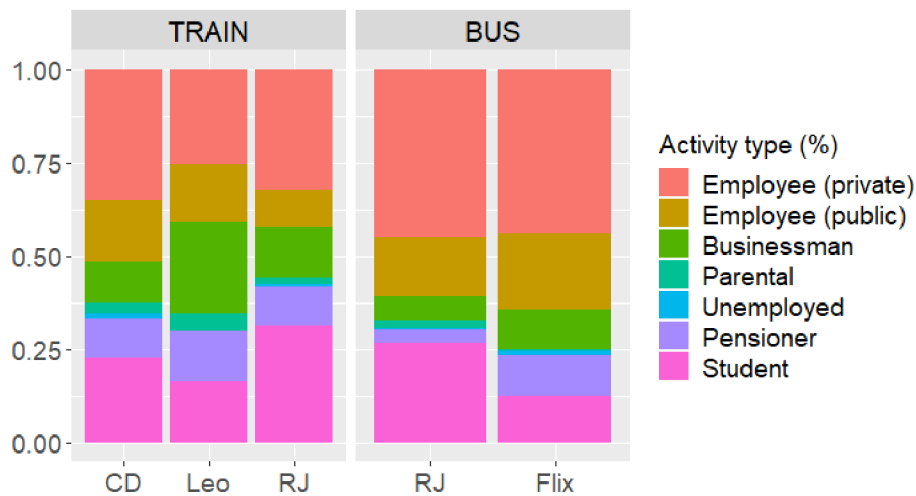
400   In summary, the structure of the passengers' economic activity played an essential role. Seniors
401   and students preferred trains, with students preferring the higher quality services provided es-
402   pecially by RegioJet trains.

5   Models and elasticity assessment

404   This section presents the results of the model estimations and computed elasticities. In our re-
405   search, the elasticity analysis represents a supplementary means of identifying the relationship
406   between the level of competition on the markets and behaviour using revealed preferences ob-
407   tained through a survey of all analysed markets.

5.1   Model estimations

409   Due to different specification of the models, the predictors differed slightly. In general, we
410   controlled for both mode and company-specific variables, including ticket price and frequency.
411   Elasticities were calculated with respect to these variables. The specification of Model 3 did
412   not enable the use of frequency. The existing alternative to Czech Railways between Brno and
413   Ostrava was only individual car transportation, which is not consistent with any frequency in-
414   formation.

415   Second, the socio-demographic characteristics were specific to individuals and did not vary
416   across modes or companies. The variables of travel purpose and passenger travel frequency
417   were used in all three models. In addition, in the Prague–Brno model, the highest completed

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418 education was used to better distinguish among the available options.[4] Last, the need to change
419 was captured as a dummy variable at the departure, the origin, or both. Detailed variable de-
420 scriptions for all three models can be found in Appendix 3.

421 Table 5 presents estimations for the final models. The interpretation varied slightly across mod-
422 els, and therefore only the sign is interpreted here. Observe that in all three models the unob-
423 served utility (or probability of choice) was lower with increasing price. The impact was sig-
424 nificantly different from zero. Connection frequency was, on the other hand, positively corre-
425 lated with the probability of choice, e.g. the utility of consumption. This parameter was, how-
426 ever, not significantly different from zero in the case of Model 1. This could be interpreted as
427 being related to the already high number of connections per day between Brno and Prague.

428 Model 1 contains both mode-specific as well as mode and company-specific variables. Moreo-
429 ver, the variables are always interpreted in comparison to a benchmark, which is in all three
430 cases the omitted option. For example, the statistically significant variable *One_day_travel* re-
431 fers to trips shorter than one full day. These consumers had lower utility for using the bus as
432 compared to the train. As can be seen, the constants were significantly lower for both bus op-
433 tions compared to Czech Railways trains. On the other hand, in the case of RegioJet trains, the
434 constant utility was higher but not statistically significant. The constant utility could with some
435 caution be interpreted as unobserved comfort. Lastly, the parameter *Tau* in the case of the nested
436 version of the discrete choice model captures the dissimilarity between options (companies) in
437 the specified groups (modes). *Tau* is always lower than one, although for the bus mode it was
438 not significantly different from one, which can be interpreted as showing a high dissimilarity
439 between bus alternatives.

[4] This was used mainly due to groups of students using bus and private train companies more often than
others.

440 Table 5 Estimation results

Variable	Company/mode	Model 1 BRQ–PRG	Model 2 PRG–OSR	Model 3 OSR–BRQ
Ln_price		−1.575** (0.73)	−0.565*** (0.212)	−1.749*** (0.435)
Ln_frequency		0.35 (0.38)	1.176*** (0.278)	
Old_X_public		0.607*** (0.203)		
One_day_travel	Bus	−0.704*** (0.165)		
Origin_change	Bus	−0.299* (0.166)		
Constant	FlixBus bus	−1.952** (0.85)		
Constant	RegioJet bus	−1.851** (0.836)		
Constant	RegioJet train	0.249 (0.463)		
Tau	Bus	0.983 (0.778)		
Tau	Train	0.603** (0.239)		
Origin_change	LeoExpress Train		−0.275 (0.368)	
Destination_change	LeoExpress Train		−2.965*** (0.684)	
Weekend	LeoExpress Train		−0.435 (0.329)	
Constant	LeoExpress Train		0.718 (0.485)	
Origin_change	RegioJet Train		0.403 (0.376)	
Destination_change	RegioJet Train		−0.833* (0.427)	
Weekend	RegioJet Train		−0.084 (0.262)	
Constant	RegioJet Train		0.005 (0.426)	
Change	CD Train			1.419*** (0.519)
Constant	CD Train			1.895** (0.953)
Number of observations		3,036	1,584	205

Note: standard errors in parentheses; asterisks (***, **, and *) correspond to the significance level (1%, 5%, and 10%, respectively). The number of observations is calculated as the number of passengers from the survey multiplied by available alternatives, i.e., we have four alternatives for PRG-BRQ and 759 surveyed passengers. For connection OSR-BRQ, we excluded travellers from abroad.

441 Model 2 explains the Prague–Ostrava market. In both cases, the constant was not significantly
442 higher in comparison to the state-owned provider. Except for the variable *Destination_change*,
443 all of the other predictors were not significantly different from zero. For both private compa-
444 nies, consumers had significantly lower utility when there was a change in destination.

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445 Again, Model 3 does not show the binary variables for travel purpose and travel frequency. The
446 need to change at the destination or origin had a positive effect on the traveller's utility, which
447 runs contrary to expectations. This can be explained by the poor alternative options. Therefore,
448 the network of the incumbent with integrated regional trains can be fully utilised for fast trains.

449 The predictive power of the models was calculated as the share of the correct choice prediction
450 compared to all predictions for the given mode and company (see Table 6). In other words, the
451 highest probability[5] for the chosen alternative was compared to the consumer's actual choice.
452 If the prediction was the same as the real choice, the fit was right, and if it was not the same,
453 the fit was not right. Last, the sum of all correct predictions was divided by the total number of
454 chosen observations for the given mode and company.

455 Table 6 Predictive power of models

Company	Mode	Model 1 BRQ–PRG	Model 2 PRG–OSR	Model 3 OSR–BRQ
FlixBus	Bus	23.5%		
RegioJet	Bus	27.9%		
Czech Railways	Train	62.2%		
RegioJet	Train	42.2%		
LeoExpress	Train		21.3%	
RegioJet	Train		48.7%	
Czech Railways	Train		68.6%	
Czech Railways	Train			87.8%
(choice == 0)	Other			75.7%

456 Model 1 correctly predicted 62.2% of all choices by travellers that used Czech Railways trains
457 on Prague–Brno connections and 42.2% for those using the second train company, RegioJet.
458 However, the model correctly predicted only 23.5% of FlixBus choices and 27.9% of RegioJet
459 bus choices. Overall, the prediction power for bus modes was lower. Similarly, the fit of Model
460 2 was better for companies with higher market shares, namely Czech Railways and RegioJet
461 trains. However, the fit was rather poor for LeoExpress trains. The best performance was pro-
462 vided by Model 3, which was able to correctly predict 87.8% of all choices for Czech Railways
463 trains.[6]

5.2   Elasticities with respect to price and frequency

465 The coefficients for prices and frequencies from Table 5 provide little explanatory value due to
466 unobserved and individual-specific utility. Therefore, the market demand elasticities for travel
467 alternatives were estimated.

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[5] For Model 3 and standard logistic regression, the threshold of 50% was used to distinguish the chosen alternative.
[6] In the case of Model 3, McFadden's R^2 was also calculated as 0.41.

468

469 Table 7 gives the calculated elasticities with respect to price for PRG-BRQ and PRG-OSR
470 routes. Table 8 shows result for the specific long-distance transport market BRQ-OSR.

471 Table 7 Elasticities with respect to price on PRG-BRQ and PRG-OSR markets

| | BRQ–PRG | | | |
Company	FlixBus	RegioJet bus	RegioJet train	Czech Railways
FlixBus	−1.12	0.47	0.32	0.30
RegioJet bus	0.44	−1.15	0.30	0.28
RegioJet train	0.29	0.29	−1.68	0.74
Czech Railways	0.39	0.39	1.05	−1.33
	PRG–OSR			
	Czech Railways	LeoExpress train	RegioJet train	
Czech Railways	−0.28	0.20	0.22	
LeoExpress train	0.10	−0.40	0.11	
RegioJet train	0.18	0.20	−0.33	

472 The interpretation of the calculated elasticities with respect to price is as follows: a 1% increase
473 in price for FlixBus would lead to a 1.12% decrease in FlixBus's share. Furthermore, the 1.12%
474 decrease in FlixBus's share would lead to a 0.44% increase in RegioJet's bus share, a 0.29%
475 increase in RegioJet's train share, and a 0.39% increase in Czech Railways' share.

476 Table 8 Elasticities with respect to price on BRQ-OSR market

| | BRQ–OSR* |
	Czech Railways
Czech Railways	−0.38

477 *Note:* The route BRQ-OSR is a different case as it does create a connection with the capital city, and further,
478 there is no alternative (competition) on this route. Thus, the computed elasticity for this route is not determined
479 for direct comparison with the results from the other two routes; however, it is still a relevant market connecting
480 two important municipalities and, in many ways, comparable to the other two markets. Therefore, we provide an
481 estimation of price elasticity also for this third market.

482 In terms of elasticity analysis, three interesting results are observable. First, the existence of
483 intermodal competition seems to have had a stronger effect on elasticity of demand than another
484 intramodal competitor did. Moreover, the results do not provide any sign of brand loyalty on
485 the part of consumers. Furthermore, the market power of Czech Railways within the Brno–
486 Ostrava connection seems to have been low with respect to price. Even though elasticity anal-
487 ysis is not stand-alone proof of any of these conclusions and each one requires separate inves-
488 tigation, the direct- and cross-price elasticities are essential indicators of the findings.

489 Table 9 presents elasticities with respect to frequency, i.e. percentual changes of connections
490 (or, in other words, capacity). A 1% increase for FlixBus connections on the Prague–Brno line
491 would increase the company's market share by 0.25%. Such an increase would, in term, reduce
492 the market shares of RegioJet buses by 0.10%, RegioJet trains by 0.07%, and Czech Railways

493 by 0.09%. In this case, the elasticities for the Prague–Brno market are not statistically different
494 from zero. As mentioned previously, the elasticities for the Brno–Ostrava market were not es-
495 timated due to the model specification.

496 Table 9 Elasticities with respect to frequency

	BRQ–PRG			
Company	FlixBus Bus	RegioJet Bus	RegioJet train	Czech Railways
FlixBus Bus	0.25	−0.10	−0.07	−0.07
RegioJet Bus	−0.10	0.26	−0.07	−0.06
RegioJet train	−0.07	−0.07	0.37	−0.16
Czech Railways	−0.09	−0.09	−0.24	0.30
	OSR–PRG			
	Czech Railways	LeoExpress train	RegioJet train	
Czech Railways	0.58	−0.42	−0.46	
LeoExpress train	−0.20	0.84	−0.24	
RegioJet train	−0.38	−0.42	0.69	

497 In general, the lower the frequency was, the higher the elasticity of change was. Therefore, even
498 though we cannot estimate elasticity with respect to frequency for the Brno–Ostrava line, the
499 expectation would be findings of a highly elastic market.

6 Findings and discussion

501 The results for prices and frequencies for different entry setups provide, at first sight, a surpris-
502 ing contradiction. First, we observe little variability in price across markets with significantly
503 different market structures. On the other hand, the findings for frequencies are in line with
504 expectations.

505 There is almost no geographic price discrimination from the incumbent Czech Railways, i.e. it
506 employs a uniform price strategy across the analysed markets. Together with conditions based
507 on PSOs, this leaves very little space for price manoeuvres by the incumbent on the monopo-
508 lised Brno–Ostrava market. [7]Therefore, we did not observe higher prices (on average) within
509 the monopolised market compared to those on the more competitive lines. Moreover, there is a
510 documented effect in the previous literature of competition on price level through, for example,
511 two observed price wars on the Prague–Brno and Prague–Ostrava lines shortly after open access
512 was introduced.

[7] Connection Brno-Ostrava is provided under a netto contract. This obligation is determined such that it transfers some risk on the provider since the Ministry of Transport does not fix the prices. The price regulation only determines maximum prices; these can be increased by 20% for a maximum of 20% of connections per day. This allows some flexibility for price determination in otherwise very stable price strategies of Czech Railways company.

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513　However, the connection frequency is a different story. There was great variation in the number
514　of connections across markets. This is in line with previous findings of equilibria with one
515　dominant firm (most likely the incumbent) and smaller entrants. Not only was the number of
516　connections per day higher in case of open access lines, but also more of the day was served.
517　This suggests that players tended to compete for both peak and off-peak times.

518　The elasticity analysis of market demand both confirmed previous findings and opened new
519　questions. First, the lack of differences in price elasticities between the monopolised market
520　and the market with three railway companies confirmed the results of the price analysis itself
521　(i.e. little price discrimination and overall low market power on the monopolised Brno–Ostrava
522　market).

523　There was, however, a striking difference in elasticities with respect to price between the Pra-
524　gue–Brno and Prague–Ostrava markets. Three possible reasons are discussed here. First, the
525　documented price war on the Prague–Brno line occurred before the survey, which may have
526　contributed to travellers' price sensitivity. Second, the intense competition on this railway line
527　was even intensified by equally tough competition between bus alternatives. Finally, there were,
528　on average, 82 connections between Brno and Prague during a regular workday. This specific
529　connection has very limited market power, which normally stems from departure time differ-
530　entiation. Therefore, market demand was highly elastic to price even for negligible changes.

531　Lastly, the market structure enabled us to test for consumers' brand loyalty. However, we did
532　not find any tendency to prefer a brand alternative to a mode alternative from a competitor. As
533　mentioned before, however, this is based on our supplementary elasticity analysis, which suf-
534　fers from several shortcomings.

7　Research implications

536　A cross-section comparison of markets with varying entry regulations and competition did not
537　show variability in price level, but did show a clear positive impact of entry on the connection
538　frequency. The monopolised PSO market did not encourage higher connection frequencies in
539　comparison to the more competitive lines. Moreover, consumers' price sensitivity was higher
540　for relevant intermodal competition. The low level of price variability between markets may
541　have had several causes; we tend to believe that one of the most important was the low monop-
542　oly power of the incumbent Czech Railways. Therefore, the market power of a sole player could
543　be reasonably reduced by combining PSOs and competition on other markets, as in the case of
544　the Brno–Ostrava line.

545　On the other hand, if a high frequency of connections is desired, it has not been achieved with-
546　out intense competition in the Czech Republic. On average, there is a train every 30 minutes on

547 competitive lines compared to a gap of more than 70 minutes on the monopolised connection.
548 Last, if possible, not only intramodal alternatives should be encouraged, but intermodality as
549 well. The closeness of substitution can play an important role in maintaining low market power.
550 This was the case for the high elasticity within the Prague–Brno line and therefore the expected
551 low market power for firms. As expected, consumers clearly benefited from competition. If
552 maximising consumer surplus is the aim for regulators and managers, competition or at least
553 some kind of competitive tendering should always be preferred.

554 Several questions remain open and provide space for further research. The effect of free entry
555 on the consumer side of welfare seems to be unquestionable. However, overall welfare is still
556 an issue. Moreover, even on markets with a relatively high number of firms, the firms remained
557 naturally differentiated with some local monopoly power due to departure time heterogeneity.
558 The question arises of how high the real market power of such firms is and what the regulatory
559 policies are on the open-access market.

8 Conclusions

561 We have provided a comprehensive analysis of the effects of different entry regulations on
562 competition and travellers' decision processes. To this end, we studied three different Czech
563 lines: Prague–Brno, Prague–Ostrava, and Brno–Ostrava. These differed significantly in both
564 railway entry policies and market structure. Moreover, the intense railway competition on the
565 Prague–Brno market was further intensified by intramodal competition with bus alternatives.

566 Our findings are in line with the existing literature describing a positive effect from railway
567 competition for consumers. However, we could not find significant price level differences
568 across markets with varying entry regulations. We believe that this is an effect of the low mo-
569 nopoly power of the incumbent Czech Railways. It seems that the incumbent's pricing policy
570 does not distinguish between routes. Given the estimated price elasticity, the policy is certainly
571 not profit maximising on these routes. The pricing strategy is based on what is fair rather than
572 what is profitable, and this strategy makes it seem unacceptable to discriminate by route. On
573 the other hand, we identified a clear relationship between entry setup and increased connection
574 frequency. Both findings are further supported by estimated market demand and firm-specific
575 elasticities. In the case of price sensitivity, there seems to have been a significant effect from
576 intramodal competition. Furthermore, intense competition increased the number of connections
577 per day significantly. On the other hand, the connection frequency was much lower on the mo-
578 nopolised PSO market. Even though we were not able to estimate elasticity there directly, we
579 expect sensitivity to market demand with respect to frequency to be reasonably high.

580 In summary, the paper contributes to the existing empirical literature on the competition and
581 regulatory effects in long-distance passenger transportation. The paper has the potential to pro-
582 vide new arguments for ongoing policy discussion on trade-offs between open access regime
583 and more traditional regulation on railways. Moreover, by collecting a vast amount of supple-
584 mentary data on prices and frequencies, together with conducted surveys, we fulfil the existing
585 gap in the academic literature on comparisons of markets under different regulatory regimes.

Acknowledgements

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727   discounts.

728 ## Appendix 1 Original passenger survey sample and questionnaire

Mode	Company	Prague–Brno	Prague–Ostrava	Brno–Ostrava
Train	Czech Railways	312	263	142
	RegioJet	201	204	
	LeoExpress	0	113	
Bus	RegioJet	202		
	FlixBus	200		
Car	-	129	18	103

729 *Note: This table shows original structure of our passenger survey.*

730 *Source: passenger survey – see chapter 3.3, authors*

731 **Questions:**
732 - Interviewer:
733   o Mode
734   o Company
735   o Time
736   o Location
737 - Interviewed:
738   o Where do you travel from and where (municipality, region)?
739   o How long are you driving?
740   o Do you use fare type?
741   o What type of fare do you have?
742   o What class are you currently traveling in (train only)?
743   o To what extent do you usually use individual transport modes or carriers when
744   traveling on the selected routes (Prague, Brno, Ostrava)?
745   o To what extent do the following reasons affect your choice of transport mode /
746   specific carrier?
747   ▪ High frequency of connections (car availability)
748   ▪ Possibility to use a customer (discount) card
749   ▪ Price
750   ▪ Speed
751   ▪ Safety of operation (accident)
752   ▪ Personal feeling of safety in the coach/vehicle (attack)
753   ▪ Reliability / Less delayed connections
754   ▪ Comfort (place for feet, etc.)
755   ▪ Level of services (refreshments, Wi-fi, steward, magazines, etc.)
756   ▪ Possibility to work in a vehicle
757   ▪ Other: …
758   o Gender
759   o Age
760   o Education
761   o Employment
762   o Driver's license holder
763

Appendix 2 Modal & Intercompany Share

765   Sample of survey modal and company shares

Mode	Company	Prague–Brno	Prague–Ostrava	Brno–Ostrava
Train	Czech Railways	31%	43%	56%
	RegioJet	22%	36%	0%
	LeoExpress	0%	20%	0%
Bus	RegioJet	23%	0%	0%
	FlixBus	24%	0%	0%
Car	-	-	-	44%

766   *Note: This table shows relative share structure of our passenger survey.*

767   *Source: passenger survey – see chapter 3.3, authors*Big data verification modal and company shares

768   based on average modal occupancy

Mode	Company	Prague–Brno	Prague–Ostrava	Brno–Ostrava
Train	Czech Railways	39%	53%	45%
	RegioJet	24%	31%	0%
	LeoExpress	0%	15%	0%
Bus	RegioJet	18%	0%	0%
	FlixBus	19%	0%	0%
Car	-	-	-	55%

769   *Note: This table shows relative share structure of big data model on modal split on relevant routes based on*
770   *general load factor according to each mode of transport.*

771   *Source: SIM card´s movement big data (Ficek, 2020)*Big data verification modal and company shares

772   based on specific company occupancy in rail (ČD, RegioJet a LeoExpress)

Mode	Company	Prague–Brno	Prague–Ostrava	Brno–Ostrava
Train	Czech Railways	39%	53%	45%
	RegioJet	24%	31%	0%
	LeoExpress	0%	15%	0%
Bus	RegioJet	18%	0%	0%
	FlixBus	19%	0%	0%
Car	-	-	-	55%

773   *Note: This table shows relative share structure of big data model on modal split on relevant routes based on*
774   *general load factor according to each mode of transport and each individual company on train market.*

775   *Source: SIM card´s movement big data (Ficek, 2020)*

776

777

778 # Appendix 3 Variable description

	Individual specific	Alternative specific	Variable description
Ln_price	Yes	Yes	Log of price in EUR, adjusted for discounts
Ln_frequency	Yes	Yes	Log of number of connections per day
Old_X_public	Yes	Yes	Interaction variable 1 for people born before 1977 and using Czech Railways at the same time, otherwise 0.
One_day_travel	Yes	No	1 if travel duration < one day, otherwise 0
Origin_change	Yes	No	1 if origin municipality for traveller is not equal to resident municipality for traveller, otherwise 0
Destination_change	Yes	No	1 if destination municipality for traveller is not equal to resident municipality for traveller, otherwise 0
Change	Yes	No	1 if destination or origin municipality for traveller is not equal to resident municipality for traveller, otherwise 0
Weekend	Yes	No	1 if day of travel is Saturday or Sunday, otherwise 0
Travel purpose fixed effects	Yes	No	A) Business trip; B) travel to work; C) study; D) family, friends; E) tourism – 1 day; F) tourism – overnight; G) private affairs; H) other
Education fixed effects	Yes	No	Elementary, secondary without qualifications, secondary with qualifications, tertiary
Travel frequency fixed effects	Yes	No	4+ times per week, 2–3 times per week, once per week, 1–3 times per month, 2–10 times per year, once per year

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