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Entry deterrence due to brand proliferation: Empirical evidence from the German interurban bus industry

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Entry deterrence due to brand proliferation: Empirical evidence from the German interurban bus industry

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Abstract

In 2016, the largest operator in the German interurban bus industry, Flixbus, acquired its major rival, Postbus. We study the effects of that takeover using route-level data covering more than 6,000 routes. We find that Flixbus, on average, provided a lower frequency of bus rides and slightly *decreased* prices after the takeover. This indicates that Flixbus pursued a strategy of preemption: to decrease residual demand for Postbus, Flixbus offered a high number of bus rides. After the takeover, Flixbus decreased the supply of transportation services and lowered the prices to compensate the consumers for the resulting increase in inconvenience costs.[1]

JEL codes: L11, L41, L92, K21, K23
Keywords: Competition, Takeover, Interurban Bus Services, Brand Proliferation, Entry Deterrence

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1 Introduction

Various European countries have recently opened up competition in the markets for interurban bus passenger transport. One example is Germany, where the industry was deregulated in 2013.[2] As a consequence, several operators entered the German market. More and more connections became available so that the market size grew rapidly. Compared to the level before the liberalization the number of travelers increased more than tenfold, reaching 24 million in 2016. During the first two years after the liberalization, the industry was characterized by a high intensity of competition. With the market exit of a large operator ("City2City") by the end of 2014, however, the market started to consolidate. At the beginning of 2015 the two largest operators, Flixbus and MeinFernbus, merged and continued to provide services under the brand name Flixbus. The company became the market leader and took over competitors like the British firm Megabus. By the end of 2016, Flixbus reached a market share of more than 70 percent and the company announced the takeover of Postbus, the largest of the remaining competitors. The date of the takeover was November 1, 2016. At the same time, BerlinLinienBus, a subsidiary of Deutsche Bahn, left the market due to low profitability. As a consequence Flixbus' market share rose to over 90% in the aftermath of the takeover.

The goal of this study is to analyze the effect of the takeover of Postbus on the industry. Our dataset contains route-level on prices and on the number of trips per route and day for more than 6,000 routes in Germany for a period between September and December 2016. We use the data to investigate the impact of the takeover on Flixbus' pricing behavior and supply. Due to the exit of Postbus and another supplier, BerlinLinienBus, who left the market by the same time, *ceteris paribus* average prices increased and the average number

[2]Deregulation progresses at different rates across the member states of the EU. For instance, France deregulated the market at the end of 2015. Augustin et al. (2014) give a general overview of the industry key figures for Germany and the United States, where long-distance bus travel has been deregulated since the 1980s. van de Velde (2009) gives an overview about the regulatory framework of several European countries like Germany, the U.K., Sweden and others. There are also various studies available examining the effects of market deregulation in single countries, e.g., Beria et al. (2014) (Italy), White and Robbins (2012) (U.K.) and Aarhaug and Fearnley (2016) (Norway).

of trips per route and day decreased. This is, however, mainly driven by the fact that those firms were low-price carriers, i.e., on those routes on which they were active, their prices were significantly lower than average. Controlling for this effect allows us to isolate Flixbus' behavior before and after the takeover. In so doing, we identify an average, significant *decrease* in Flixbus' price-levels and a drastic, highly significant decrease in Flixbus' average daily supply of trips per route.

These findings seem counterintuitive at first glance, especially against the background of Flixbus' dominant position in the market. Based on standard merger analysis (e.g., Farrell and Shapiro (1990)) one would expect that Flixbus *increases* prices due to the gains in market power. We explain these findings by preemption in the context of a differentiated goods (Salop) model (Schmalensee, 1978; Eaton and Lipsey, 1979). That is, Flixbus used its first-mover advantage to render market entry unprofitable on some routes by offering a high number of trips per day. Flixbus was thus able to charge relatively high prices because the consumers' inconvenience costs were low. Given that the interurban bus market is rather small, Postbus was thus not able to establish a sufficiently large customer base to run a profitable business and, at some point, left the market.[3] After the takeover, the threat of entry was eliminated. The supply of trips per route and day declined and prices decreased accordingly.

Several authors have analyzed the developments in the German interurban bus market. Dürr and Hüschelrath (2015) analyze the industry in 2015 with regards to the number of operators and the routes they provide, prices, market concentration as well as potential abuses of market power. Dürr et al. (2016) conduct an ex-ante analysis regarding the merger between MeinFernbus and Flixbus in 2015 that predicts increasing average prices post-merger.

[3] An example that illustrates the difficulties an entrant to the interurban bus industry faces is the British firm Megabus. The provider ordered buses worth 20 million pounds in 2015, while forecasting operating losses to increase from 4 million pounds in 2015 to 10 million pounds in 2016 (see Stagecoach Group plc annual report 2015, p. 14). In 2016, Megabus reported operating losses of 24 million pounds, which is about 14 million pounds higher than the forecast. This additional loss occurred because of the establishment of further inter-city connections that turned out not to be profitable (see Stagecoach Group plc annual report 2016, p. 16).

Although our findings regarding the takeover of Postbus differs from their prediction about the merger they analyze, there is a general consensus about Flixbus' dominant position in the market. Based on a descriptive analysis of intramodal and intermodal competition in passenger transport, Knorr and Lueg-Arndt (2016) state that welfare gains would arise from the deregulation of the German interurban bus industry due to lower prices for passenger transport on average. Böckers et al. (2015) predict that competition between interurban bus and railway passenger transport operators leads to decreasing prices for long-distance rail passenger transport in Germany, which indicates that there exists a strong intermodal competition between the two modes of transport. Beestermöller (2017) identifies that railway strikes in Germany had a persistent, positive effect on the ticket sales in the interurban bus industry. Bataille and Steinmetz (2013) show that competition between interurban bus and railway passenger transport operators on some routes may lead to railway connections on other routes, where no bus travel is provided, to become unprofitable. This effect arises from network effects in railway passenger travel. Our findings indicate that prices in the interurban bus industry significantly decrease on routes where there are alternative rail connections available. We therefore provide empirical evidence for the prevalence of intermodal competition between railway and interurban bus passenger transport.

Against this background, our contribution to the literature is that not only increasing but also decreasing price levels after takeovers or mergers may actually be a sign of market power, especially in differentiated goods markets such as the German interurban bus industry. Decreasing prices alone are thus not necessarily an indication of welfare gains. In a broader context, our results indicate that, the variety (i.e., frequencies on a given route in the transport sector) has to be taken into consideration in order to evaluate market power and welfare.

The analysis is structured as follows. In Section 2 we provide a brief overview of the German interurban bus industry. We present the data, descriptive statistics and empirical findings in Section 3. Section 4 contains a theoretical model that explains our empirical findings. Section 5 concludes. Robustness checks and proofs can be found in the Appendix.

2 The German Interurban Bus Industry

The goal of this section is to provide the reader with background information about the interurban bus industry in Germany. We present the evolution of the industry starting with the opening of competition in the market in 2013 until 2016, when Flixbus acquired Postbus.

Period I: Prior 2013

Prior to the liberalization in 2013, the German interurban bus market was characterized by a very limited route network. This was due to regulations that had been introduced to protect rail traffic from competition. Only international connections and connections from and to former West Berlin were permitted. In addition to these connections there was a small number of routes for which suppliers could receive approval, e.g., Airport Shuttles. BerlinLinienBus, a Deutsche Bahn subsidiary, and Deutsche Touring were the two largest companies on the market at the time before the liberalization. In the course of the political discussion about the liberalization of the market, DeinBus started offering regular bus services using a legal loophole in December 2009. The connections were organized as carpool rides, and have been approved by a court decision in 2011. In April 2012 MeinFernbus began to operate its first route after an official approval being granted (see for example Dürr and Hüschelrath (2017) for an general overview of the industry development).

Period II: 2013 - 2014

In 2013, competition was opened up in the industry. According to the amended version of the German Passenger Transport Act, all connections may be approved if the distance between two successive stops is at least 50 kilometers (km). An exemption for shorter connections might be granted where no regional train connections with a travel time of less than one hour are available. Such an exemption furthermore requires that there are insufficient local transport services available or that only a small loss in demand for railway passenger transport is expected.[4]

Demand has grown rapidly after the liberalization process started, and several companies have entered the market. The resulting high competitive pressure forced some suppliers to leave the market or to merge with larger competitors. In February 2013, Flixbus entered the Market. City2City, a subsidiary of British National Express, and ADAC Postbus, a joint venture of the automobile club ADAC and Deutsche Post, entered in April and November 2013, respectively. In contrast to Flixbus and MeinFernbus, whose main business model was to offer their services to consumers with lower income such as students, ADAC Postbus addressed more demanding customers at that time (see Bundesamt für Güterverkehr (2015, 2016) for a comprehensive overview of entries and exits).

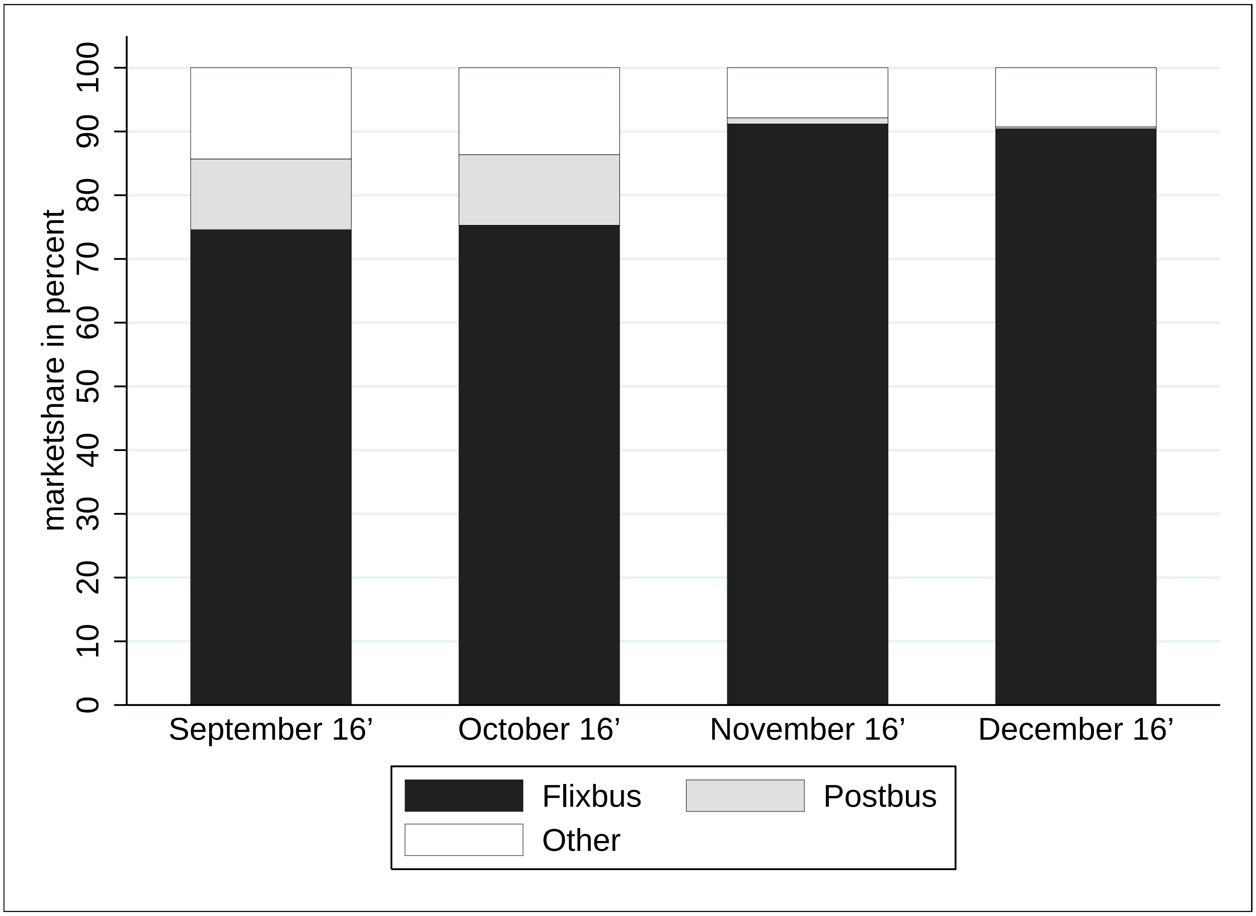
In October 2014, City2City was the first large operator to leave the market. One month later, in November 2014, ADAC withdrew from a joint venture with Deutsche Post. Deutsche Post thus continued to offer their services under the brand name Postbus. Postbus' business model of offering a high quality transport service for relative high prices turned out not be profitable. The operator then started to act more aggressively by offering lower prices and by regularly granting rebates. Although the number of suppliers started to shrink, Megabus, which is part of the British Stagecoach Group, entered the market in December 2014 (Bundesamt für Güterverkehr, 2015).

Period III: 2015 - Fall 2016

At the beginning of 2015, the market structure changed significantly because of the merger of the two largest operators, Flixbus and MeinFernbus. The merged entity offered their services under the brand name Flixbus after a short transition period. In Summer 2016, Flixbus announced the takeover of Megabus. At this point the two main competitors of

[4] According to §42a Personenbeförderungsgesetz every connection with at least two successive stops more than 50 km apart is not considered short-range public transportation anymore.

Figure 1: Market shares before and after the takeover on November 1, 2016.



Flixbus were Postbus and BerlinLinienBus. However, BerlinLinienBus left the market in November 2016 due to low profitability. Finally, Postbus was taken over by Flixbus on November 1, 2016 (Bundesamt für Güterverkehr, 2016). This event is the object of our analysis.

Figure 1 depicts the market shares on a monthly basis from September to December 2016. These figures are calculated using our dataset which will be described in Section 3. The numbers indicate that Flixbus became a quasi-monopolist after the takeover. Only smaller competitors operating solely on a regional level (e.g., DeinBus) were also active in the industry. The licenses for Postbus' routes were acquired by Flixbus whereas a small number of BerlinLinienBus' routes were transferred to IC Bus, another Deutsche Bahn subsidiary.

3 Empirical Analysis

In this section, we will present our empirical analysis. We first describe our dataset and outline some descriptive statistics. In what follows the main part of the empirical analysis will be presented, i.e., the effects of the takeover.

Data

The dataset underlying our analyses was constructed upon using `busliniensuche.de`, one of the leading online search engines for interurban bus travel in Germany. Our data includes information on travel date, provider, origin and destination as well as on duration and prices of more than 8000 routes in Germany.[5] After excluding routes that are offered less than once per week and provider, 6105 routes remain in the dataset. The search engine also provides data about train connections of Deutsche Bahn. Information about carpool travel are collected using the online platform of BlaBlaCar, `https://www.blablacar.de/`, which is the most prominent provider in Germany. We will use data carpool travel as a means to control for a potential time trend in prices and frequencies in the interurban bus market.

We cluster the providers in three groups, i.e., Flixbus, Postbus and Others. The latter group contains all operators except for Flixbus and Postbus (e.g., BerlinLinienBus or Deinbus). The dataset contains average prices for all providers, all available route, and each day during the period from September 5 to December 11, 2016. The data was collected upon requesting the transportation service five days prior to the respective day of departure.[6] We started collecting the data before BerlinLinienBus announced its market exit. We are thus not able to distinguish between BerlinLinienBus and other providers contained in the group Others. This article analyzes the takeover of Postbus so that this lack of identifiability does not affect our results.

[5]Following Dürr et al. (2016), we define routes as each combination between two different stops on a route (e.g. Hamburg to Munich) and count outward and inward trips as two separate routes. If one provider offers the same route more than once per day, we aggregate the data on provider level per day.

[6]Dürr and Hüschelrath (2015) use a similar approach. They find not much variation in the data when varying the time span between booking and the day of departure.

Descriptive Statistics

The average price for using an interurban bus service was €15.71 prior to the takeover, and the average price per km was €-cents 5.67. The evolution of the average prices is depicted in Figure 2. The vertical line represents the date of the takeover. In order to analyze the competitive environment before the takeover, each route is assigned to one of 6 subgroups as follows.

1. 3851 routes provided only by Flixbus (on average €-cents 6.08/km)
2. 219 routes provided only by Postbus (€-cents 4.33/km)
3. 402 routes provided by Flixbus and Postbus (€-cents 4.96/km)
4. 658 routes provided by Flixbus and Others (€-cents 6.37/km)
5. 134 routes provided by Postbus and Others (€-cents 5.72/km)
6. 839 routes provided by Flixbus, Postbus and Others (€-cents 5.07/km)

After the takeover, three types of routes remain. First, there are routes solely provided by Flixbus. These routes are potentially formed from the former subgroups 1, 2 and 3. Second, some routes that potentially emerged from the former subgroups 4,5 and 6 are provided by Flixbus and the group Others after the takeover. Thirdly, from the same subgroups 4,5 and 6, there may have emerged routes only provided by suppliers from the group Others after the takeover. Note that, regarding subgroup 2, only 5 routes provided by Postbus before the takeover were adopted by Flixbus. The following routes, 5251 in total, were provided after the takeover.

- 4479 routes provided only by Flixbus (on average €-cents 5.90/km)
- 717 routes provided by Flixbus and Others (€-cents 6.12/km)

- 55 routes provided only by Others (€-cents 14.55/km)[7]

Before turning to a detailed analysis of the evolution of prices in the industry, it seems appropriate to examine some aggregate numbers first. The following figure summarizes the industry-wide price effects of the takeover on an aggregate level.

Figure 2: Average prices by operator in €-cents per km.

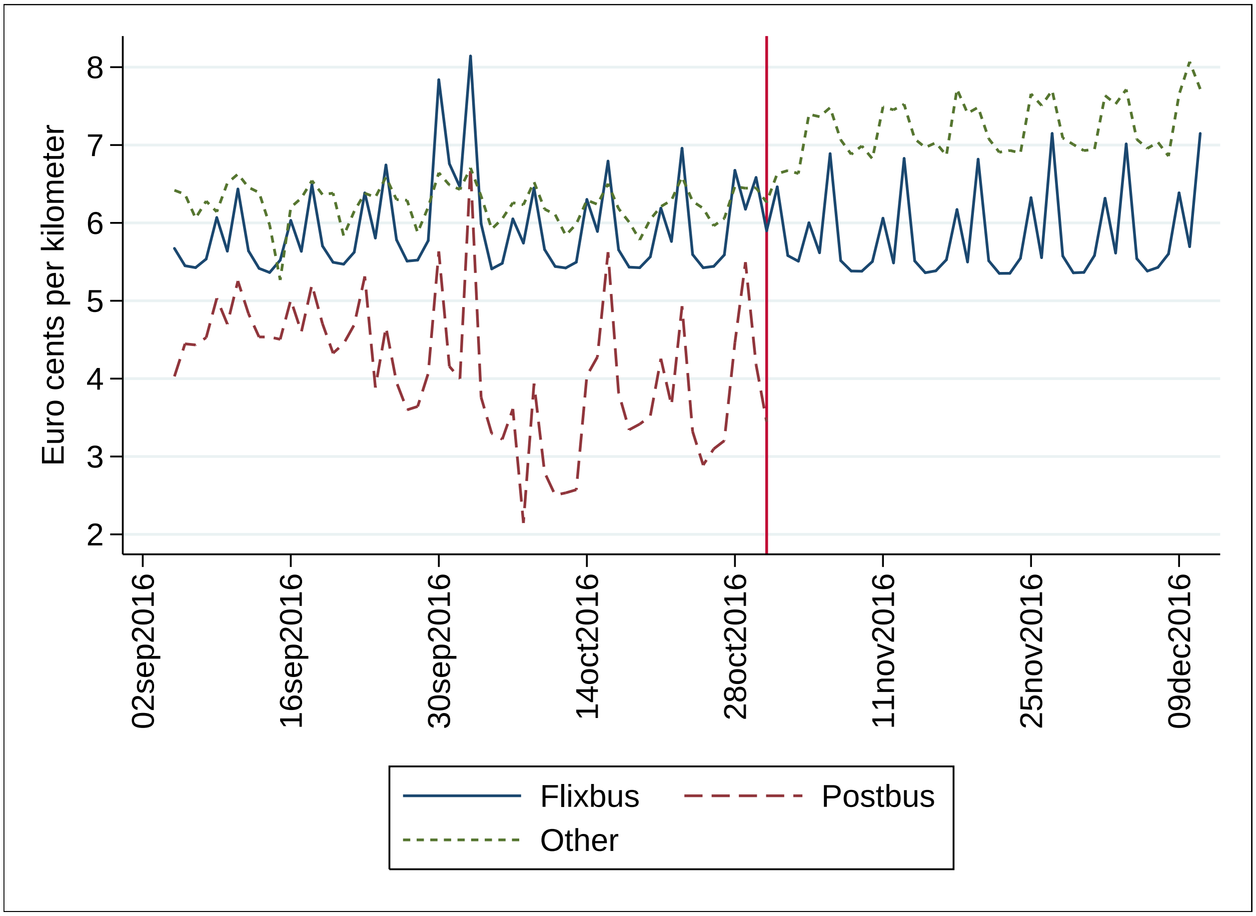


Figure 2 shows the average prices by operator in €-cents per km. Postbus left the market on November 1, 2016. One can see that despite the other operators increased their prices on average, it seems that Flixbus's prices remained rather constant in the aftermath of the takeover. Anticipating our empirical results, which will be presented and explained in the

[7] Average prices in this group are very high because the demand for most of these routes is low, e.g., small sections of international connections such as Dresden to Görlitz.

remainder of this article, we even identify a significant *decrease* in Flixbus' average prices after the takeover.

We now present a more detailed overview of the effects of the takeover based on the groups defined above. Figure 3 depicts average prices by group and operator. The increase in prices on October 3, 2016 and the previous weekend can be explained by public holidays, as discussed below in more detail, and occurs in all groups. In groups 1 and 3, one can see that prices spiked more strongly after the takeover.[8] Regarding group 2, one can see that after Postbus leaves the market Flixbus charges higher prices. Given Flixbus adopted only a small number of routes, the increase in average prices may be traced back to the operator providing only those of Postbus' former routes which were relatively profitable. A similar picture emerges in group 5, where the prices charged by other providers drastically increased on average. In group 4, Flixbus' average prices show more pronounced spikes whereas the average price of the other providers drastically increase. The same pattern can be observed in group 6: Postbus leaves the market, Flixbus' average prices spike more strongly, and the average prices charged by other operators show an increasing trend.

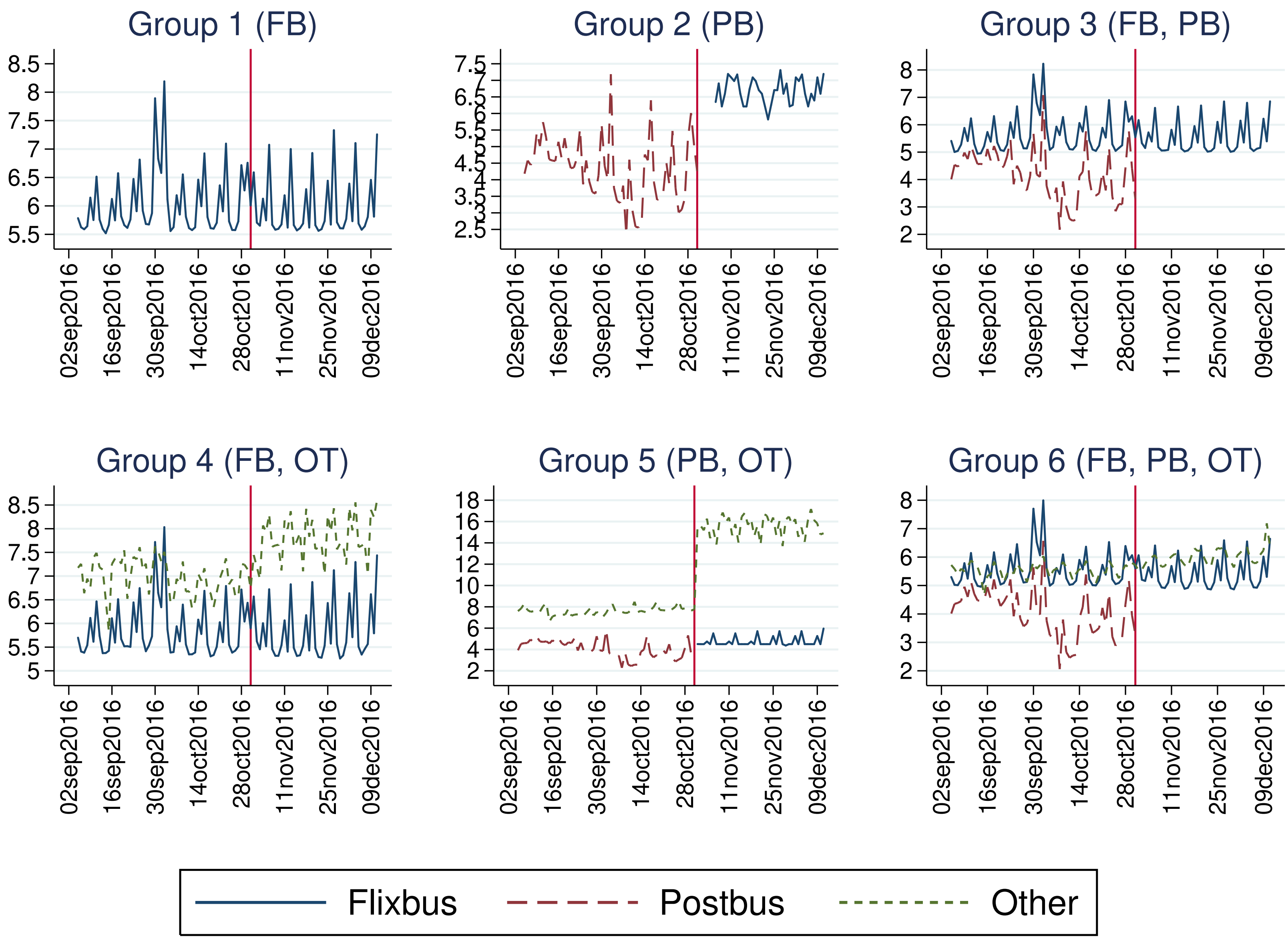
In the light of these observations, we identify an average increase in industry-wide prices from approximately 5.67 €-cents before to 6.02 €-cents after the takeover. However, this has two potential reasons. First, Postbus and BerlinLinienBus were low-price carriers. If these suppliers leave the market *ceteris paribus* average prices will unambiguously increase in the industry. Second, Flixbus and the remaining suppliers (Others) may have increased prices as a consequence of the reduction in the number of operators in the market. In what follows we isolate these effects and evaluate their impact on the industry after the takeover.

Prices

In this section we examine the impact of the takeover on prices. As a first step, we analyze industry-wide prices using a fixed-effects panel regression. The structural equation takes the

[8] Note that there was a small number of 7 out of 3851 routes where other providers became active after the takeover. Their prices and supply of routes are not included in Figures 3 and 4, respectively.

Figure 3: Price effects per group and operator in €-cents per km



following form:

$$\ln p_{i,j,t} = X_t'\beta_1 + \delta_1 D_{TO,t} + \delta_2 D_{PB,j} + \alpha_i + \epsilon_{i,j,t}. \tag{1}$$

In equation (1) the dependent variable is the logarithm of daily average prices per km. Prices are given for each route i and provider j at day t. The matrix X_t includes dummies for each day of the week (Dürr et al., 2016). Given that Monday, October 3, 2016, was a national public holiday in Germany, we also include a dummy variable to control for potential effects on prices arising from that holiday. The dummy variable $D_{TO,t}$ is 0 before and 1 after the takeover. The coefficient δ_1 therefore captures the effect of the takeover on the prices of the remaining operators. We also include a dummy variable $D_{PB,j}$ that takes the value 1 if the corresponding provider of the route is Postbus and takes the value 0 otherwise. The coefficient δ_2 thus depicts the (percentage) difference between Postbus' prices from the industry average. All time-invariant heterogeneity between different routes, e.g., sociodemographic characteristics of the cities, is absorbed by the route fixed-effects α_i. Table 1 presents the results of regression (1). In total we have 664,165 observations.

We find a strong increase in average prices on weekends of roughly 14% (5.5%, 18.9%) on Fridays (Saturdays, Sundays). This is in line with Dürr et al. (2016) who find that demand for interurban bus services is higher on weekends. Over the course of the public holiday weekend of October 3, 2016 this increase was even more pronounced: prices increased further by about 13.1% relative to normal weekends.

The coefficient δ_1 is not significantly different from zero, thus, there is no indication that the average prices of the remaining competitors changed. This finding is puzzling because one would expect price increases arising from the increase in concentration on the supply side. Moreover, as indicated above, there is also a direct effect on average prices due to the (low-price operator) Postbus leaving the market. That Postbus was indeed a low-price operator is confirmed by the coefficient δ_2, which indicates that Postbus' prices were approximately

Table 1: Price determinants - Fixed-effect panel regression results

	Coefficients	(Standard Errors)
D_{Monday}	0.0560***	(0.00137)
$D_{Wednesday}$	-0.00671***	(0.00108)
$D_{Thursday}$	0.0216***	(0.00109)
D_{Friday}	0.140***	(0.00170)
$D_{Saturday}$	0.0555***	(0.00125)
D_{Sunday}	0.189***	(0.00208)
D_{PH}	0.131***	(0.00139)
D_{PB}	-0.357***	(0.00568)
D_{TO}	0.000275	(0.00126)
Constant	1.657***	(0.00139)
Observations	664165	
R^2	0.288	

The estimation is performed using GMM. The dependent variable is the daily average, logarithmic price per km. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistical significance is: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

35.7% below the average price level of the industry.

Given this upward pressure on average prices, we now examine Flixbus' prices after the takeover. To do so, we estimate equation (1) only for groups 1 and 3, where Flixbus was the sole operator and where Postbus and Flixbus were active before the takeover, respectively. The following results are based on estimations which only contain data on Flixbus in groups 1 and 3.

In Table 2, the coefficients of the dummy variable D_{TO} (which corresponds to δ_1 in (1), although the estimations are performed using data on groups 1 and 3 only) are significantly negative for both groups. This implies that Flixbus *decreased* its average prices after the takeover by 0.5% compared to the pre-takeover level on routes where Flixbus was the sole operator. On routes where Postbus and Flixbus were active before the takeover prices decreased by 0.9%. Based on standard merger analysis one would expect that, in general,

Table 2: Price determinants groups 1 and 3 - Fixed-effect panel regression results

	Coefficients	(Standard Errors)	Coefficients	(Standard Errors)
D_{Monday}	0.0503***	(0.00124)	0.0505***	(0.00249)
$D_{Wednesday}$	-0.00307***	(0.000857)	-0.00377	(0.00203)
$D_{Thursday}$	0.0262***	(0.00130)	0.0192***	(0.00277)
D_{Friday}	0.135***	(0.00214)	0.160***	(0.00543)
$D_{Saturday}$	0.0499***	(0.00140)	0.0665***	(0.00363)
D_{Sunday}	0.195***	(0.00288)	0.224***	(0.00712)
D_{PH}	0.149***	(0.00192)	0.195***	(0.00454)
D_{TO}	-0.00581***	(0.000992)	-0.00942***	(0.00247)
Constant	1.677***	(0.00122)	1.619***	(0.00278)
Observations	310783		36617	
R^2	0.233		0.358	
	Group 1		Group 3	

The estimations are performed using GMM. The dependent variable is the daily average, logarithmic price per km. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistical significance is: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Flixbus would increase prices after the takeover.[9] We explain this finding in Section 4.

We performed several estimations to check the robustness of the results presented in Table 2. Anticipating the results, all robustness checks yield a drop in Flixbus' average prices in the range of 0.5% to 2%. In general, decisions to take over a competitor and to exit the market are driven by expected profits and, therefore, by prices. To test whether the results of our estimations are affected by endogeneity we apply the heteroscedacity based instrumental variable (IV) approach suggested by Lewbel (2012). There is no indication that our results might be affected by endogeneity because the results show only minor differences to the results presented in Table 2. To control for a potential time trend that is independent of the takeover we apply a difference-in-differences approach using carpool travels as a control

[9]Price decreases are possible when the takeover, or merger, creates synergies reducing the operator's marginal costs (Farrell and Shapiro, 1990). Given that Postbus' business was basically shut down it seems unlikely that such synergies resulted from the takeover.

group.[10]. The results do not qualitatively differ from the results presented in Table 2 which indicates that our results are not attributed to a time trend. As a further robustness check, we examine the evolution of prices by means of a balanced panel. We estimate equation (1) again including only routes that were available before and after the takeover. Again, the results do not differ from those shown in Table 2. All robustness checks are presented in more detail in Appendix A.

Our results indicate that due to the exit of Postbus and BerlinLinienBus the average price level in the industry increased after the takeover. However, we do not find evidence that Flixbus increased prices after the takeover. In fact, we observe a drop in Flixbus' average price level on routes where Flixbus was either the sole operator or where Postbus and Flixbus were active.

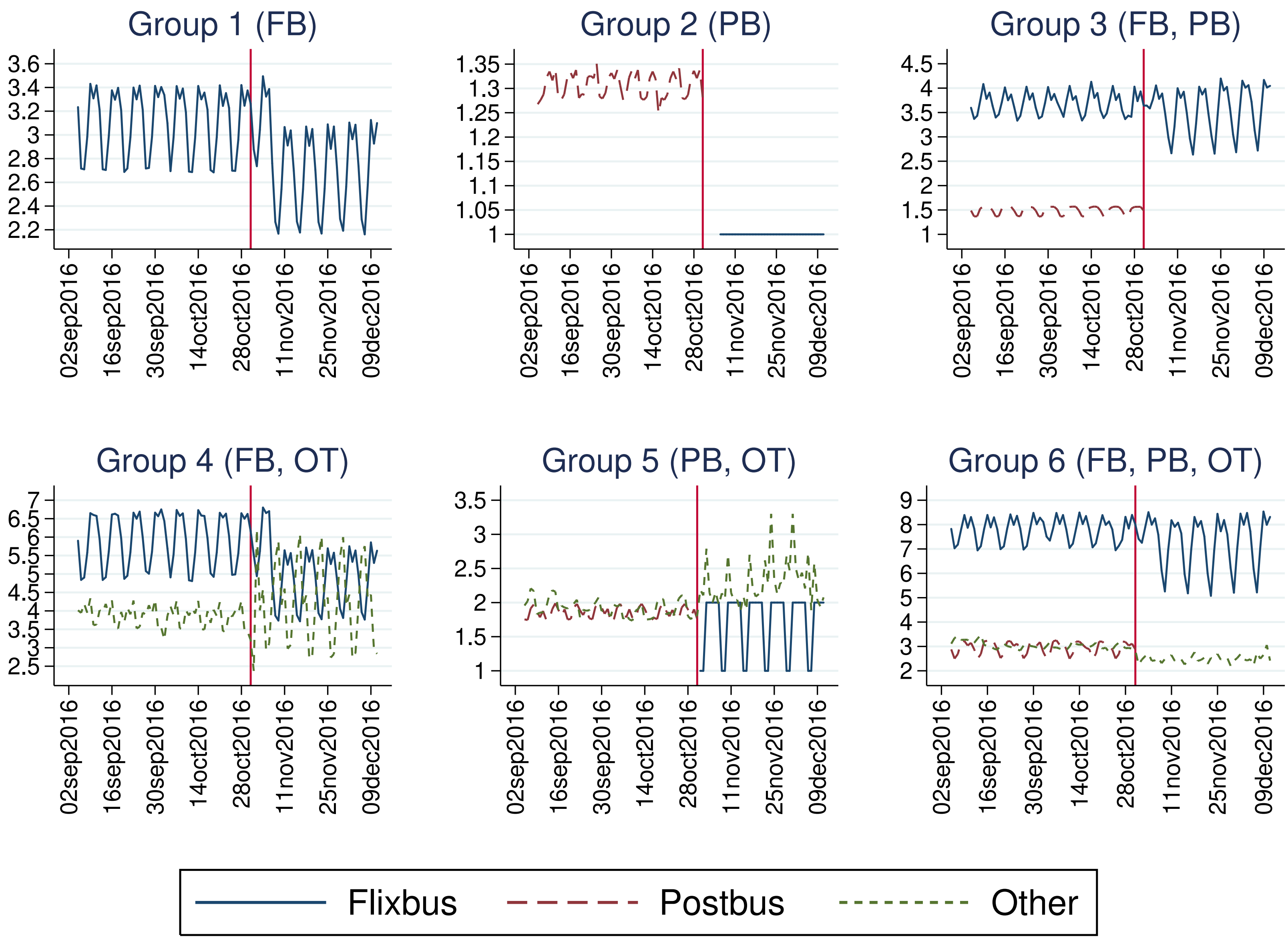
Frequencies

Now that the effects of the takeover on prices are examined, the next step is to analyze how the takeover affected the supply of bus travel. The latter can be interpreted as frequency defined as the number of trips per route and day and per operator.

Figure 4 displays the number of trips per route and day for each operator distinguished according to the groups defined in Section 3. One can see that Flixbus reduced the frequency on those routes where it was solely active (group 1). Before the takeover, there was an average number of 3.11 bus rides per day whereas after the takeover the number dropped to 2.75 trips per day. Postbus provided 1.31 bus rides on average per day in group 2. Between November 1, 2016, and November 5, 2016, there has been no regular service on these routes. On November 6, 2016, Flixbus started to provide a small number of former Postbus routes with an average of one bus ride per day. The average number of trips per day and route was 4.91 trips before the takeover on routes that were provided by Flixbus and Postbus (group 3). That number dropped to 3.56. On routes provided by Flixbus and Others (group 4), the

[10] For a more detailed discussion of our approach see Appendix 5.

Figure 4: Number of daily trips per route by group and operator.



average daily number of trips amounted to 8.69 before and 6.19 after takeover. The routes provided by Postbus and Others were driven 3.46 times per day before and 2.37 times after the market exit of Postbus. On routes where all providers have been active, on average 13.01 trips have been offered per day before the takeover and 8.10 after the takeover.

The industry-wide average daily number of trips over all routes and providers was about 5,31 before and 4.23 after the takeover, i.e., there is a decline in the supply of bus rides of about 20%. However, as is the case for prices in the industry, this observation can partly be traced back to Postbus' exit from the market. We also observe that all remaining providers reduced the number of trips per route and day to an average of 3.94 (Flixbus) and 3.07 (Others). This finding is counterintuitive because, e.g., in a Cournot market, the output of the remaining firms should increase when a supplier leaves the market. To explain this finding, we first perform a fixed-effects panel regression on the industry-level, i.e., containing data on all groups 1-6. The structural equation of our model takes the following form:

$$\ln q_{i,j,t} = X_t' \rho_1 + \lambda_1 D_{PB,t} + \lambda_2 D_{TO,t} + \alpha_i + \nu_{i,j,t} \tag{2}$$

In equation (2) the dependent variable is the logarithm of the number of trips provided by firm j on route i on day t. Note that, in this estimation, we distinguish between each operator and not between groups of operators. The matrix X_t includes dummy variables for each day of the week and a dummy variable for the public holiday October 3, 2016. As in the analysis of prices the dummy variable $D_{PB,t}$ is 1 if the supplier of the respective route is Postbus, and is zero otherwise. The dummy variable D_{TO} takes the value 0 (1) before (after) the takeover. The coefficients λ_1 and λ_2 thus capture the difference in Postbus' daily supply of routes compared to the industry average and the effect of the takeover on the remaining operators' average supply of bus rides, respectively. All time-invariant heterogeneity between different routes, e.g., sociodemographic variables, is absorbed by the route fixed-effects α_i.

Table 3 shows that the daily average number of trips per route of the remaining operators dropped significantly by approximately 6.8%, which is in line with our observations explained

Table 3: Frequencies - Fixed-effect panel regression results

	Coefficients	(Standard Errors)
D_{Monday}	0.110***	(0.00396)
$D_{Wednesday}$	-0.0122***	(0.00250)
$D_{Thursday}$	0.0948***	(0.00391)
D_{Friday}	0.189***	(0.00401)
$D_{Saturday}$	0.151***	(0.00398)
D_{Sunday}	0.172***	(0.00423)
D_{PH}	0.00562***	(0.000940)
D_{PB}	-0.531***	(0.0185)
D_{TO}	-0.0675***	(0.00436)
Constant	0.876***	(0.00391)
Observations	664165	
R^2	0.107	

The estimation is performed by using a GMM. The dependent variable is the daily frequency expressed in logarithms per route and per provider. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * p < 0.05, ** p < 0.01, *** p < 0.001.

above. As a next step, we focus on data from groups 1 and 3, i.e., those groups where Flixbus was the sole operator and where Flixbus and Postbus were active before the takeover, respectively. This allows to evaluate Flixbus' service provision after the takeover.

Table 4 presents the results of our regressions for those routes contained in groups 1 and 3. Note that, similar to Section 3, these figures only contain data on Flixbus. One can see that, on average, Flixbus decreased the daily number of trips per route by about 9% and 5.7% in groups 1 and 3, respectively. These indicates that Flixbus reduced the frequency especially on those routes not provided by another operator before the takeover as well as on those routes that were only provided by Flixbus after the takeover.

These findings are puzzling for two reasons. First, routes where Flixbus was the sole operator should not be affected by the takeover because the firm is a monopolist on these

Table 4: Frequencies groups 1 and 3 - Fixed-effect panel regression results

	Coefficients	(Standard Errors)	Coefficients	(Standard Errors)
D_{Monday}	0.144***	(0.00537)	0.119***	(0.0163)
$D_{Wednesday}$	-0.0172***	(0.00269)	-0.0280*	(0.0116)
$D_{Thursday}$	0.106***	(0.00479)	0.113***	(0.0143)
D_{Friday}	0.208***	(0.00584)	0.240***	(0.0160)
$D_{Saturday}$	0.184***	(0.00544)	0.182***	(0.0150)
D_{Sunday}	0.211***	(0.00584)	0.200***	(0.0150)
D_{PH}	0.0166***	(0.00145)	0.00710	(0.00370)
D_{TO}	-0.0907***	(0.00397)	-0.0565***	(0.0128)
Constant	0.670***	(0.00403)	0.908***	(0.0119)
Observations	310783		36617	
R^2	0.131		0.110	
	Group 1		Group 3	

The estimations are performed using a GMM regression. The dependent variable is the daily frequency expressed in logarithms per route and per provider. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * p < 0.05, ** p < 0.01, *** p < 0.001.

routes before and after the takeover in group 3. There would be adjustments in frequency if, e.g., these routes constituted contestable markets, i.e., there was a threat of entry. Second, in a traditional market with, e.g., (symmetric) Cournot competition, *ceteris paribus* a monopolist's quantity should be above that of a Cournot-duopolist. This implies that Flixbus' frequency should increase after the takeover. However, our observations are not in line with these explanations. In Section 4 we therefore provide a model in which an incumbent firm in a differentiated goods market may pursue a strategy of entry deterrence.

We conduct the same robustness checks for our analyses in this section as for the analyses of prices (see above). That is, we employ Lewbels IV method, perform a difference-in-differences estimation with carpool travel as a control group, and we estimate equation (2) again in a balanced panel. All results are presented in Appendix A. We find similar effects as in 4, with the decrease in frequencies ranging from 4% to 9% in groups 1 and 3.

Intermodal Competition

As a last step of our empirical analysis we examine the role of intermodal competition. Traveling by train and carpool travel can be considered close substitutes to interurban bus transport.[11] That there exists intermodal competition between train and interurban bus transport was already pointed out by, e.g., Beestermöller (2017). Figure 5 shows that after the initial increase in the demand for interurban bus travel from 2013 to 2015, the number of passengers requesting interurban bus services has only grown by a small amount from 2015 to 2016. One can also see that between 2013 and 2014 the number of passengers traveling by train decreased slightly, which indicates that there may exist a substitution pattern between interurban bus and train travel. However, from 2015 to 2016 there has been a relatively strong increase in the number of railway passengers again. The numbers in 2016 were above the level before the liberalization of the interurban bus industry in 2013.

To control for the effect of close substitutes – railway connections and carpool travel – on the prices in the interurban bus industry we perform a fixed-effects panel regression. The structural equation of this regression takes the following form:

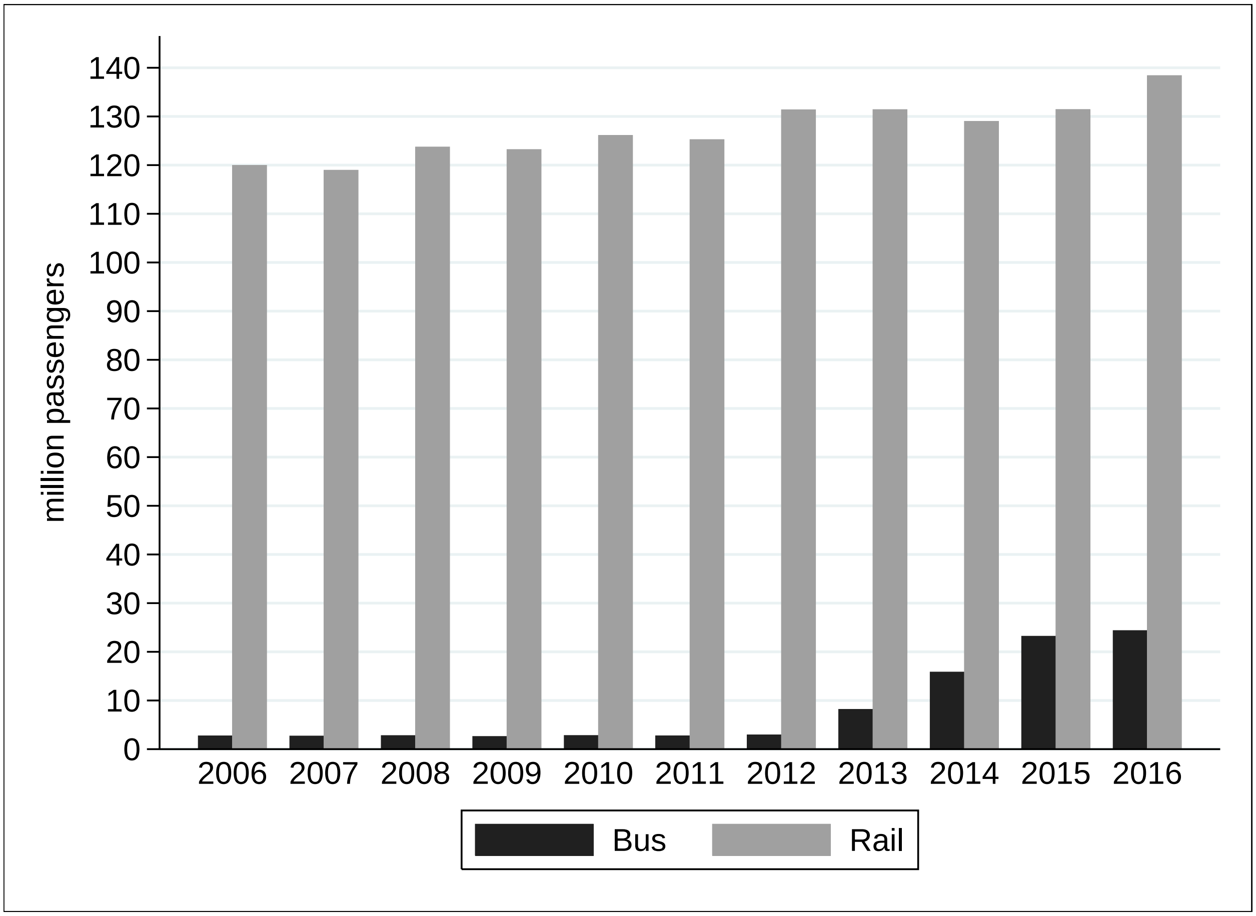
$$\ln p_{i,j,t} = X_i'\theta_1 + \gamma_1 D_{Rail,i} + \gamma_2 D_{RailChange,i} + \gamma_3 D_{SCJ,i,t} + \eta_t + \zeta_j + \mu_{i,j,t}. \quad (3)$$

The dependent variable in equation (3) is the logarithm of daily average prices per km for each route i provided by operator j at day t. The matrix X_i contains socio-demographic covariates for each route, i.e., population and the share of population under 25 years of age as well as private purchasing power in Euros. We also control for the duration of the journey (in minutes), distance (in meters) and squared distance for each route. Similar to Dürr et al. (2016), the dummy $D_{RailDirect,i}$ takes the value 1 for each route for which there is

[11]On some routes such as Cologne - Berlin as well as Munich - Berlin, domestic flights are available. However, we do not take into account this type of transport in our analyses because – if not booked several weeks in advance – fares are usually far above those for bus transport.

[12]see `https://goo.gl/vM8wct`. For 2016 date see press release of February 21, 2017, `https://goo.gl/vEOX6z`.

Figure 5: Number of interurban bus and rail passengers from 2006 to 2016. Source: Federal Statistical Office of Germany. The values for 2016 are preliminary.[12]



a direct railway connection available and is 0 otherwise. The dummy variable $D_{RailChange,i}$ takes the value 1 for routes for which there only is a railway connection available with one changeover. Otherwise, $D_{RailChange,i}$ is zero. If shared car journeys are available at day t on route i the dummy variable $D_{SCJ,i,t}$ is 1. Otherwise, it take the value zero. All time-variant heterogeneity is absorbed by the time fixed effect η_t. Heterogeneity between providers is absorbed by the provider fixed-effect ζ_j.

Table 5 presents the results for the regression of equation (3). The coefficients for $D_{RailDirect}$ and $D_{RailChange}$, γ_1 and γ_2, are significantly negative, hence, the availability of an alternative railway connections has a negative impact on prices in the interurban bus industry. On average, the availability of an alternative rail connection on a given route

Table 5: Price influences of railway - Fixed-effect panel regression results

	Coefficients	(Standard Errors)
$Population$	-1.55e-08***	(2.92e-09)
$Population < 25$	-0.871***	(0.226)
$PPP\ per\ Capita$	-0.00000214	(0.00000128)
$Duration$	0.000171***	(0.0000497)
$Distance$	-0.00000205***	(8.59e-08)
$Distance^2$	1.38e-12***	(8.05e-14)
$D_{RailDirect}$	-0.0758***	(0.00938)
$D_{RailChange}$	-0.0491***	(0.00861)
D_{SCJ}	0.0000248	(0.00336)
Observations	664,165	
R^2	0.454	

Dependent variable is daily average price per kilometer and is expressed in logarithm. The regression includes time fixed-effects as well as provider fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * p < 0.05, ** p < 0.01, *** p < 0.001.

decreases the average prices for interurban bus travel by about 7.6% for direct connections and 4.9% for connections with one changeover, respectively. This indicates that consumers perceive railway travel as a close substitute to interurban bus travel, thus, the market size for interurban bus services is to a large extent limited by train connections. The consumers' outside option is therefore affected by railway passenger transport, which becomes relevant in Section 4.

A different picture emerges with respect to carpool travel: the coefficient of D_{SCJ} does not significantly differ from zero. We explain this finding as follows. Railway connections are a stable alternative to interurban bus travel whereas share car journeys are generally not offered on a regular basis. Although some consumers may perceive share car travel as a substitute, we cannot identify a systematic pattern of substitution to interurban bus travel. Thus, it seems that interurban bus service providers do not systematically react to the carpool travel market.

The direction of the coefficients of the socio-demographic covariates and of the duration as well as distance are in line with the ones reported by Dürr et al. (2016). We include these variables in our regression only to control for heterogeneity. The reader is thus directed to their article for a detailed discussion.

4 Theory

The purpose of this section is to explain our main finding, namely, that Flixbus offered a lower number of bus rides per day and connection for a slightly lower price after the takeover. Against the background of a typical merger analysis, this finding is counterintuitive because one would expect increasing prices when, *ceteris paribus*, concentration in an industry increases. To explain this result we think of a bus ride as a differentiated product. Throughout the following analysis we focus on two aspects of product differentiation. First, consumers perceive alternative times of arrival as distinct variants of the transportation service. If a consumer has to meet an appointment at 3:00 pm, arriving at 2:30 pm might be a sweet spot for her. If the only available bus arrives at 2:55 pm she incurs inconvenience costs. Shy and Stenbacka (2006) impose a similar assumption on how consumers perceive shopping hours of supermarkets. Second, consumers may have different valuations for time. For instance, business travelers usually have a higher preference towards a shorter traveling time than leisure travelers (Yang and Zhang, 2012, p. 1323).

Our data covers a time period where Flixbus and Postbus offered various connections in Germany. A single connection will be considered a horizontally differentiated goods market. In the following model, prices and locations are endogenously determined. There is a first- and a second-mover. One could think of Flixbus as the first- and of Postbus as the second-mover. This central assumption is discussed in the next paragraph in more detail. The first mover is the incumbent in the industry. The incumbent firm may deter entry in order to become the market leader. In the model, entry deterrence is achieved by preemption by "product proliferation". That is, the first-mover renders market entry unprofitable by committing to offer a large variety of products (Wilson, 1992). After the takeover of the entrant, the incumbent firm acts as an (unconstrained) monopolist. We will show that there exists an equilibrium where entry deterrence can be achieved with high prices and a high number of bus rides on a given route. In particular, the monopolistic number of bus rides is lower than the deterrent number of bus rides in this equilibrium, i.e., product variety decreases after a takeover.

Based on the evolution of the industry, which was outlined in Section 2, a central assumption to our model is that Flixbus acts as a first-mover in the location *and* in the price dimension. In that respect, our model differs from the canonical literature on product differentiation where the first-mover commits to offer a certain number of variants or where variety is exogenously given (Neven, 1987; Wilson, 1992; Salop, 1979b).[13] Our assumption can be justified as follows. First, Flixbus was the incumbent firm whereas Postbus was an entrant to the industry, which indicates that Flixbus was the price leader. Second, Flixbus' pricing was constrained by intermodal competition (see Section 3). In order to establish a long-term alternative to train transport, Flixbus had an interest in offering stable prices. Third, Flixbus' pricing was based on algorithms which were designed to optimally react to demand fluctuations.[14] Changing these algorithms frequently would be costly. Moreover, a fourth reason could be that Flixbus preferred to avoid price increases after becoming the market leader. Price increases may lead to consumer search as, for instance, in Cabral and Fishman (2012), with the result of consumers switching to other modes of passenger transport such as train, car or plane.

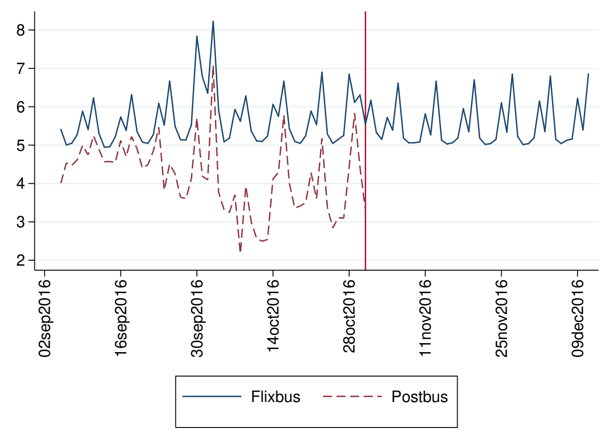
Figure 6 shows that, based on our data, the first-mover assumption is justified. The figure depicts the prices per km of Flixbus (solid graph) and Postbus (dotted graph) from

[13] Price commitment is also analyzed, for instance, by Hagiu (2006) in the context of two-sided markets. In our model, price increases result from the takeover if the incumbent instead commits to offer a certain number of bus rides. This result will be shown below and suggests that a decrease in the number of bus rides (a smaller variety) and an increase in prices after the takeover are two sides of the same coin.

[14] See `https://www.flixbus.com/company/press-room/press-releases-flixbus-5-years-anniversary` (last accessed July 17 2018)

September 2 until December 9, 2016. One can see that, despite a spike in prices around the end of September and the beginning of October, prices of Flixbus are rather stable whereas the prices of Postbus fluctuate more strongly.[15]

Figure 6: Prices per km charged by Postbus and Flixbus on those routes where both firms are active.



A single route is characterized by a circular city (Salop) model (Schmalensee, 1978; Eaton and Lipsey, 1979). Suppose there is a total number of L consumers uniformly distributed along a circle with unit circumference. For expositional convenience, and to maintain generality, we refer to Flixbus as the incumbent firm, indexed $i = 1$, and to Postbus as the entrant, indexed $i = 2$, throughout the following analysis. A single bus ride is referred to as an outlet in the context of the model. Prices are denoted p_i, $i \in \{1, 2\}$, and an outlet's location of firm i is denoted by l_i.[16]

The desired location of a given consumer is denoted l^*. The consumer incurs quadratic inconvenience costs per unit of distance $t(l^* - l_i)^2$, where $t > 0$ is a finite constant, as is the case in various Hotelling or Salop models (Bonanno, 1987; Neven, 1987).[17] Let u denote the consumer's gross valuation for the transport service. The consumer's utility function thus

[15]The spike in prices can be explained by public holidays, which constitutes an exogenous increase in demand (See Section 3).

[16]It will become obvious that, in order to derive our main results, it is sufficient to focus on two locations.

[17]Assuming linear transport costs makes the analysis much less tractable due to discontinuities in demand (d'Aspremont et al., 1979).

reads

$$U(l_i, l^*) = u - t(l^* - l_i)^2 - p_i. \tag{4}$$

The marginal costs for transporting an additional passenger are zero. However, offering an additional bus ride entails fixed costs F (setup costs per outlet). Moreover, there are also (sunk) entry costs S. Those entry costs account for regulatory approval procedures. According to industry experts, the costs of obtaining approval to establish a new interurban bus connection in Germany ranges between a medium to a high six-figure sum.[18]

The utility obtained from consuming the outside good is normalized to zero.[19] The outside good is exogenously given and affects the market size of the interurban bus industry by capturing alternative transportation services. These alternatives are, first, going by car in which case utility is influenced by exogenous factors such as fuel prices. A second and third alternative would be traveling by plane and train, respectively. It is hard to imagine that prices and departure times of domestic flights respond to changes in the interurban bus industry. This is because the supply of domestic flights is limited by larger cities with an airport. Moreover domestic flights in Germany are typically targeting business customers due to their short traveling times and relatively high prices.[20] Regarding competition by train, our empirical results suggest that the closest competitor to the interurban bus carriers is Deutsche Bahn. However, Deutsche Bahn is regulated and thus able to respond to the developments in the interurban bus market only to a limited extent.[21]

The game's timing can be summarized as follows. On stage 1 the incumbent chooses a price p_1, the number of outlets, n, and the outlets' locations. On stage 2, the entrant decides whether to enter the market or not. In case of entry the entrant charges a price p_2 and

[18]See `https://goo.gl/VgNbf9` (last accessed July 17 2018)

[19]If the outside good yields positive utility, one can reformulate the problem by defining the willingness to pay for the good as the absolute utility from consumption minus utility obtained from consuming the outside good (Salop, 1979a).

[20]See, for instance, `https://www.goeuro.com/travel/transport-price-index-2016` (last accessed on July 17, 2018)

[21]Deutsche Bahn's price schedules are typically changed on a yearly basis.

chooses how many outlets to operate. If there is no entry, the entrant's profits are zero.

We now turn to our analysis. Consider first a situation where the incumbent behaves as an unconstrained monopolist. This constitutes the market environment without the threat of entry, i.e., after the takeover. Given the market is fully covered and the distance between each shop is equal the monopoly price satisfies

$$p(n) = u - \frac{t}{4n^2}. \tag{5}$$

Given (5), the monopolist's profit $\pi(p(n), n) = Lp(n) - Fn$ is maximized for

$$n_M \equiv \left(\frac{Lt}{2F}\right)^{\frac{1}{3}} \tag{6}$$

with the ensuing monopoly price

$$p_M \equiv u - \left(\frac{F^2 t}{16L^2}\right)^{\frac{1}{3}}. \tag{7}$$

Expressions (6) and (7) constitute the optimal number of outlets n_M and prices p_M from the viewpoint of an unconstrained monopolist.[22] If the incumbent chooses n_M and p_M when the entrant is active in the market, the latter may respond in way that the incumbent may even be driven out of the market. Anticipating the entrant's response, it is reasonable to assume that the incumbent firm tries to deter entry.

In the literature, the canonical Hotelling location game where locations and prices are chosen on stages 1 and 2, respectively, two general cases are identified (see, e.g., Economides et al. (1986); Tirole (1988); Böckem (1994)): (i) the entrant may prefer to operate its outlets close to those of the incumbent or (ii) entry may occur midway between the incumbent's

[22]Throughout the analysis we will treat the number of outlets n as a continuous variable. However, n is in fact an integer so that for any solution n^* one would have to compare profits for the floor and the ceiling of n^*. This can lead to slight deviations with respect to the result that the incumbent's profits have to be at or below entry costs S to deter entry (see below). However, similar to Salop (1979a), this does not qualitatively impact our results because neither does the incumbent incur losses nor is there enough free space for profitable market entry when the optimal, integer-valued number of outlets is $\lfloor n^* \rfloor$ or $\lceil n^* \rceil$.

outlets. The first and the second case can be interpreted as minimum and maximum product differentiation, respectively. Lemma 1 states the condition which determines whether, in case of entry, the entrant prefers to locate its outlets midways between or close to those operated by the incumbent. All proofs can be found in Appendix B.

Lemma 1. *The entrant prefers to locate its outlets midway between the incumbent's outlets if and only if* $p_1 \leq \frac{3t}{4n^2}$.

The result can be interpreted as follows. A central driver of the entrant's incentive to induce minimum product differentiation is the business stealing effect. The magnitude of this effect decreases in t and in the absolute distance between the firms' outlets.[23] That is, the business stealing effect becomes weaker the higher the perceived degree of product differentiation captured by the consumer transportation costs. According to Lemma 1 there exists an upper bound $\frac{3t}{4n^2}$ which ensures maximum product differentiation. This upper bound increases in t, i.e., it becomes more likely that the entrant locates as far away as possible from the incumbent because the incentive for business stealing effect is then less pronounced. The opposite is true with respect to n. The upper bound decreases in n because the distance between the incumbent's outlets (i.e., the degree of product differentiation) becomes smaller.

In the light of Lemma 1, increasing the number of variants n has two opposing effects. On the one hand, the incumbent is able to charge higher prices by introducing new variants because consumers' transportation costs decrease. On the other hand, with high prices and a large number of variants, the incentive for the entrant to be active in the market by introducing variants similar to those of the incumbent is relatively strong. Throughout the following analyses, define by n_D and p_D the number of outlets and the price in case of entry deterrence, respectively.

Case (i): We first examine the case of minimum product differentiation that arises if the

[23] To see this, consider $l_1 = 0$ and any location $l_2 > 0$. The indifferent consumer is then located at $z = \frac{l_2}{2} + \frac{p_2 - p_1}{tl_2}$. The term $\frac{p_2 - p_1}{tl_2}$ constitutes the business stealing effect.

entrant is active in the market. In cases where entry occurs close to the incumbent's chosen locations the entrant marginally undercuts the incumbent. In that case, provided the market is fully covered, the entrant will serve all customers. Entry deterrence thus requires that the following condition holds.

$$L(p_D - \epsilon) - Fn_D - S \leq 0 \tag{8}$$

Condition (8) states that the entrant's profit from charging a price $p_D - \epsilon$, $\epsilon \to 0$, has to be non-negative for entry to be deterred. By locating each outlet marginally close to the incumbent's outlets, the entrant's number of outlets is n_D. In addition to the setup costs F for each outlet, the entrant incurs entry costs S. It also follows from (8) that the incumbent's profit in case of entry deterrence, $Lp_D - Fn_D$, has to be approximately at or below S because otherwise entry occurs. A similar result is presented by Salop (1979a) with $S = 0$.

In order to ensure that condition (8) is satisfied, the incumbent can adjust two variables, i.e., the price p_D and the number of outlets n_D. This implies that the incumbent's strategy is not uniquely determined. It is thus possible to obtain results where prices decrease or increase after the takeover, as will be shown below. Consider first a situation where the incumbent charges the monopoly price p_M and accordingly operates n_D outlets in order to deter entry. As argued above, this may be the case when the incumbent prefers to offer a stable price level to increase customer satisfaction or to avoid adjustments of pricing algorithms.[24]

Entry deterrence by charging the monopoly price p_M is consistent with our empirical observations when the number of outlets n_D exceeds the number of outlets an unconstrained monopolist would choose, n_M.[25] Lemma 2 states a lower bound $\underline{n}$ on the number of outlets above which entry is deterred, i.e., for all $n_D \geq \underline{n}$, given the price is p_M.

[24]Such a situation seems especially plausible in our analysis because Flixbus did not run own buses but rather works with different subcontractors (See https://www.trainline.eu/information/flixbus; last accessed July 3, 2018). This suggests that adjustments to the number of bus rides on a given route is relatively cheap.

[25]Recall that with p_M and n_M the market was fully covered thus the market will also be fully covered for $p_D = p_M$ and $n_D \geq n_M$.

Lemma 2. *The monopoly price* p_M *as defined in* (7) *occurs in an equilibrium with entry deterrence if and only if* n_D *exceeds*

$$\underline{n} = \frac{Lu - S}{F} - \left(\frac{Lt}{16F}\right)^{\frac{1}{3}}. \tag{9}$$

The lower bound of the number of outlets $\underline{n}$ as depicted in (9) decreases in the entry costs S. This implies that the higher entry costs S the lower the minimum number of outlets in order to deter entry, i.e., it becomes easier for the incumbent to defend its monopoly position. Given that an unconstrained monopolist's number of outlets n_M (see (6)) is independent of S, the result that the incumbent's number of outlets decreases after a takeover is *less* likely to occur when entry costs S are high. Formally, $\underline{n} \geq n_M$ follows if and only if

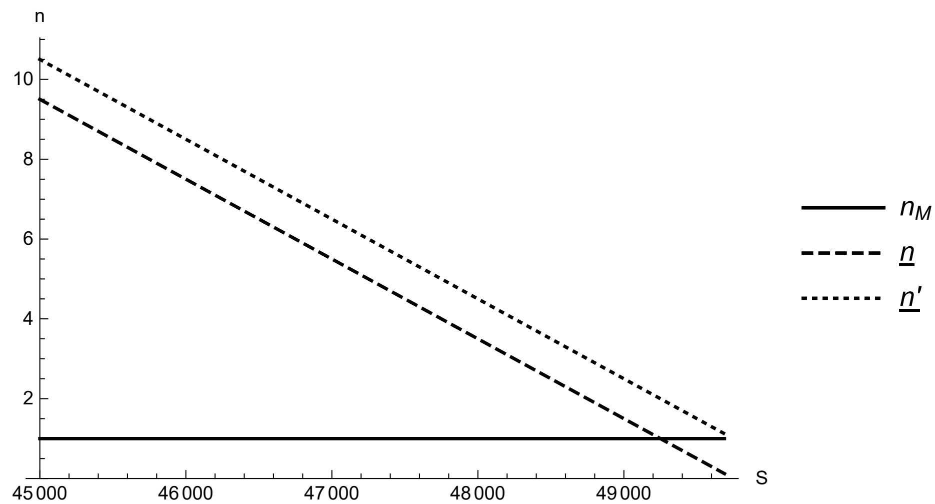
$$S \leq Lu - \frac{3}{2}\left(\frac{F^2 Lt}{2}\right)^{\frac{1}{3}}. \tag{10}$$

To illustrate our result, consider the following parameter values. Assume the daily market for an interurban bus service that connects two cities that are 800 km apart (for instance, Munich and Hamburg). One could assume that, per day, there may be a total number of $L = 1,000$ potential bus travelers, each one willing to pay at most $u = 50$ per bus ride. Suppose that the costs of providing a single bus on this route is $F = 500$ and that $t = 1$. The ensuing monopoly price is $p_M = 49.75$, which yields a price per km of 6.22 Euro-cents. This is in line with our observations (see Section 3). Given these parameter values, the upper bound of entry costs S below which the result $\underline{n} \geq n_M$ occurs is 49250 (see (10)), which, as outlined above, is also in line with anecdotal evidence about the costs of regulatory approval. Using the condition that $p_M > \frac{3t}{4n}$ from Lemma 1, minimum product differentiation always occurs in the relevant range where $\underline{n} \geq n_M$.[26] Figure 7 shows the minimum number of outlets $\underline{n}$ as a function of S.

The solid line in Figure 7 depicts the monopolistic number of outlets, n_M, which is one

[26] With the given numbers $p_M > \frac{3t}{4\underline{n}}$ approximately holds for all $S < 49,688.6$ and $S > 49,811.4$. Figure 7 is thus restricted to $S < 49,688.6$.

Figure 7: Number of outlets chosen by a monopolist n_M and the minimum number of outlets that ensures entry deterrence $\underline{n}$ as a function of entry costs S.



in our example. The dashed line depicts $\underline{n}$ as explained above. That is, for all S below the intersection point of the solid and the dashed line, it holds that $n_M \leq \underline{n}$ so that the number of outlets in case of deterrence ($n_D \geq \underline{n}$) would be (weakly) greater than the number of outlets chosen by a monopolist. In that range, variety would decrease after a takeover. The dotted line shows the minimum number of outlets $\underline{n}'$ such that the incumbent can charge a deterrent price of $p_D = p_M + 0.5$, i.e., a price which is roughly 1% above the monopoly price. This would lead to a decrease in prices after the takeover, which is consistent with our observations. One can see that such a result is also consistent with a decrease in variety (i.e., a lower number of bus rides per day and route) when sunk costs are approximately below $S = 49750$.[27]

At this point it becomes obvious that our results would still hold if the incumbent chose a price other than p_M in order to maintain a monopolist's number of variants n_M in case of entry deterrence. From (8), there exists an upper bound for the deterrent price $p \leq \frac{S}{L} + \left(\frac{F^2 t}{2L^2}\right)^{\frac{1}{3}} \equiv \overline{p}$. Accordingly, an increase in prices after the takeover, i.e., $\overline{p} \leq p_M$, occurs if (10) holds. In our model, a price increase after the takeover is therefore equivalent to a

[27]The result can be derived as follows. Suppose that the deterrent price is $p_D = p_M + x$. To ensure deterrence, $L(p_M + x - \epsilon) - Fn_D - S \leq 0$ (see (8)), which yields $\underline{n}' \equiv \frac{L(u+x)-S}{F} - \left(\frac{Lt}{16F}\right)^{\frac{1}{3}}$. With the given parameter values and $x = 0.5$, the intersection point between $\underline{n}'$ and $n_M = 1$ is $S = 49,750$.

decrease in the number of variants.

We have shown that our empirical findings are in line with an entry deterrence strategy that is characterized by product proliferation. Such a strategy constitutes a form of "innocent" entry barriers (Salop, 1979b; Neven, 1987). From a theoretical perspective, offering a large number of bus rides and higher prices in the pre-takeover phase is consistent with a drop in the supply of bus rides on a given route in combination with slightly decreasing or constant prices in the post-takeover phase.

For completeness, consider case (ii), where maximum product differentiation arises in case of entry. It will be shown that the empirically identified effects of the takeover cannot occur in equilibrium in case (ii). Proposition 1 states n_D and p_D for the case of maximum product differentiation.

Proposition 1. *Suppose the entrant operates its outlets midway between those of the incumbent. Then, entry is deterred if the incumbent chooses*

$$n_D = \frac{2St}{Lu^2 - 2Ft} \quad \textit{and} \quad p_D = u - \frac{(Lu^2 - 2Ft)^2}{16S^2t}. \tag{11}$$

Proposition 1 implies that the price p_D for which entry is deterred increases in entry costs S. This is intuitive because entry is costly when S is high, which allows the incumbent to charge a high price without triggering entry. However, this also requires that the incumbent operates a high number of outlets. Otherwise, the market would not be fully covered and the entrant could attract those consumers not served by the incumbent. Consequently, n_D also increases in S. Recall that the monopolistic number of outlets n_M and price p_M are constant in S (See (6) and (7)). Corollary 1 follows from Lemma 1 and Proposition 1. It states that a result where $n_D \geq n_M$ cannot occur in an equilibrium with maximum product differentiation in case of entry.

Corollary 1. *There exists no equilibrium where* $n_D \geq n_M$ *and* $p_D \leq \frac{3t}{(2n)^2}$ *for all* $n_D = \frac{2St}{Lu^2-2Ft}$ *and* $p_D = u - \frac{(Lu^2-2Ft)^2}{16S^2t}$.

5 Conclusion

Interurban bus transport has recently become a more and more relevant mode of passenger transport in Europe. The goal of this article was to analyze a takeover in Germany's interurban bus industry, i.e., the takeover of Postbus by Flixbus. After the takeover, Flixbus became a dominant supplier with a market share above 90%.

One would expect that such a takeover would result in lower supply and higher prices. We indeed identify a significant decrease in the daily supply of bus rides per route and day as well as an average increase in the industry-wide price level. The decrease in the supply and the increase in prices, however, is *per se* not surprising. This is because Postbus, who left the market, was a low-price carrier. The exit of that operator unambiguously increases the industry-wide average price level and decreases the average supply of bus rides per route and day.

We isolate Flixbus' conduct in the aftermath of the takeover. A striking finding is that Flixbus' prices remained rather stable – we even identify a slight decrease in prices after the takeover. Flixbus also provided a lower number of trips per route and day. These findings are counterintuitive. Based on, e.g., a symmetric, homogeneous goods Cournot-model one would expect an increase in the supply of each remaining supplier in the market as well as an increase in prices when the market becomes more concentrated.

We explain our findings by means of a Salop model. We interpret Flixbus as the incumbent firm who attempts to deter entry on some routes by pursuing a strategy of product proliferation. That is, the incumbent offers a high number of bus rides (variety) such that entry does not pay off. This high variety leads to relatively low inconvenience costs for the consumers, which allows the incumbent to charge the monopoly price (or even higher prices) without rendering market entry profitable. The incumbent may choose to offer a (unconstrained) monopolist's variety without major changes in prices after the threat of entry is eliminated.

Our results have implications for merger analyses because, from an economic perspective, a takeover is very similar to a merger. Despite the merging firms charging constant or even decreasing prices post-merger, the merger might have caused a decline in consumer surplus when variety decreases. We cannot quantify welfare in our example because we do not have data on the exact number of passengers, i.e., we cannot assess market demand. However, our results emphasize the importance of variety, especially in differentiated goods market such as passenger transport.

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Appendix A

Endogeneity As a robustness check for potential endogeneity, we apply the heteroscdacity based IV approach as suggested by Lewbel (2012). This method can be used to identify structural parameters in models with endogenous regressors if no traditional identifying information, e.g., external instruments, are available. In this context, identification is achieved by having regressors that are uncorrelated with the product of heteroskedastic errors. Instruments are constructed as simple functions of the model's data.[28] We use this method to instrument the potentially endogenous variable $D_{TO,t}$. Tables 1, 2, 3 and 4 contain the estimation results of the corresponding Lewbels' IV regressions for prices and frequencies in groups 1 and 3, respectively.

The Kleibergen-Paap statistic suggests that the instruments are sufficiently strong because the critical values for weak identification are exceeded by far.[29] These results do not indicate the presence of endogeneity.

Time Trend To control for a time trend that is independent of the takeover we apply a difference-in-differences approach by using share car journeys as a control group. This assumption seems justified because also the German authority for transport identifies share car journeys as a substitute to interurban bus services (Bundesamt für Güterverkehr, 2017). We apply this method for prices and for daily frequencies. The structural equation of our model has the following form for the prices:

$$\ln p_{i,j,t} = X_t'\beta_1 + \psi_1 D_{TO,t} + \psi_2 D_{BUS,j} + \psi_3 D_{BUS,j} D_{TO,t} + \alpha_i + \omega_{i,j,t}. \tag{1}$$

The corresponding equation for the daily number of trips per route is:

$$\ln q_{i,j,t} = X_t'\beta_1 + \chi_1 D_{TO,t} + \chi_2 D_{BUS,j} + \chi_3 D_{BUS,j} D_{TO,t} + \alpha_i + \sigma_{i,j,t}. \tag{2}$$

[28] For a short introduction to this method we refer to Baum et al. (2012)

[29] The null hypothesis of the Kleibergen-Paap test is that the structural equation is under-identified (i.e., the rank condition fails). Critical values are taken from Stock and Yogo (2002). As a rule of thumb a value for the test statistic above ten indicates identification of the model.

Table 1: Lewbel's IV regression – Prices group 1

	Coefficients	(Standard Errors)
D_{Monday}	0.0536***	(0.000901)
$D_{Wednesday}$	0.000961	(0.000824)
$D_{Thursday}$	0.0307***	(0.000804)
D_{Friday}	0.140***	(0.000943)
$D_{Saturday}$	0.0529***	(0.000855)
D_{Sunday}	0.196***	(0.00110)
D_{PH}	0.146***	(0.00185)
D_{TO}	-0.0211***	(0.00112)
Observations	310783	
R^2	0.231	
Weak identification test:		
Kleibergen-Paap rk Wald F statistic	1277.467	
Stock-Yogo (2002) critical values:	5% max. IV rel bias 19.86	
	10% max. IV size 31.50	

The dummy variable D_{TO} is instrumented using an heteroscedasticity based IV method (Lewbel, 2012). The estimation is performed using a 2-step GMM. The dependent variable is the daily average price per km, per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The dependent variable is the logarithm of daily average prices per km and the daily number of trips, respectively. Prices (number of trips) are given for each route i and provider j at day t. The dummy variable $D_{Bus,j}$ takes the value 1 if the provider is Flixbus and is zero otherwise (i.e., for carpool travel). The matrix X_t includes dummies for each day of the week and a dummy variable for the public holiday and the weekend prior to that holiday. The dummy variable $D_{TO,t}$ captures the takeover effects. All time-invariant heterogeneity between different routes, is absorbed by the route fixed-effects α_i. Tables 5, 6, 7 and 8 respectively present the results of our regressions for prices and frequencies in groups 1 and 3, respectively. In total we have 936,101 observations.

The daily effects and the effect of the public holiday on the average prices and frequencies

Table 2: Lewbel's IV regression – Frequencies group 1

	Coefficients	(Standard Errors)
D_{Monday}	0.142***	(0.00176)
$D_{Wednesday}$	-0.0112***	(0.00205)
$D_{Thursday}$	0.104***	(0.00177)
D_{Friday}	0.202***	(0.00174)
$D_{Saturday}$	0.177***	(0.00173)
D_{Sunday}	0.204***	(0.00174)
D_{PH}	0.0172***	(0.00164)
D_{TO}	-0.0865***	(0.00151)
Observations	310783	
R^2	0.131	
Weak identification test:		
Kleibergen-Paap rk Wald F statistic	1277.467	
Stock-Yogo (2002) critical values:	5% max. IV rel bias 19.86	
	10% max. IV size 31.50	

The dummy variable D_{TO} is instrumented using a heteroscedasticity based IV method (Lewbel, 2012). The estimation is performed using a 2-step GMM. The dependent variable is the daily number of connections per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

are similar to those reported in Section 3. These results support the assumption that share car journeys initially experience the same trend and thus, are a appropriate control group. However, we find no (highly) significant overall effect of the takeover, neither on average prices nor on the number of daily trips. This suggests, that there is no time trend which is independent of the takeover because such a trend should also effect the control group.

Balanced Panel As a last robustness check, we examine prices and frequencies using a balanced panel: We estimate equation 1 (equation 2) again including only routes that were served before and after the takeover. The results confirm the findings in Section 3 and are stated below.

Table 3: Lewbel's IV regression – Prices group 3

	Coefficients	(Standard Errors)
D_{Monday}	0.0555***	(0.00233)
$D_{Wednesday}$	0.00215	(0.00208)
$D_{Thursday}$	0.0254***	(0.00202)
D_{Friday}	0.167***	(0.00248)
$D_{Saturday}$	0.0696***	(0.00223)
D_{Sunday}	0.227***	(0.00286)
D_{PH}	0.193***	(0.00504)
D_{TO}	-0.0251***	(0.00182)
Observations	36617	
R^2	0.356	
Weak identification test:		
Kleibergen-Paap rk Wald F statistic	242.976	
Stock-Yogo (2002) critical values:	5% max. IV rel bias 19.86	
	10% max. IV size 31.50	

The dummy variable D_{TO} is instrumented using an heteroscedasticity based IV method (Lewbel, 2012). The estimation is performed using a 2-step GMM. The dependent variable is the daily average price per km, per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4: Lewbel's IV regression – Frequencies group 3

	Coefficients	(Standard Errors)
D_{Monday}	0.117***	(0.00562)
$D_{Wednesday}$	-0.00906	(0.00632)
$D_{Thursday}$	0.117***	(0.00563)
D_{Friday}	0.230***	(0.00513)
$D_{Saturday}$	0.169***	(0.00503)
D_{Sunday}	0.191***	(0.00524)
D_{PH}	0.0157**	(0.00509)
D_{TO}	-0.0410***	(0.00310)
Observations	36617	
R^2	0.108	
Weak identification test:		
Kleibergen-Paap rk Wald F statistic	242.976	
Stock-Yogo (2002) critical values:	5% max. IV rel bias 19.86	
	10% max. IV size 31.50	

The dummy variable D_{TO} is instrumented using a heteroscedasticity based IV method (Lewbel, 2012). The estimation is performed using a 2-step GMM. The dependent variable is the daily number of connections per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * p < 0.05, ** p < 0.01, *** p < 0.001.

Table 5: Difference-in-differences regression – Prices group 1

	Coefficients	(Standard Errors)
D_{Monday}	0.0364***	(0.00111)
$D_{Wednesday}$	-0.00434***	(0.000887)
$D_{Thursday}$	0.0203***	(0.00117)
D_{Friday}	0.0950***	(0.00171)
$D_{Saturday}$	0.0362***	(0.00134)
D_{Sunday}	0.136***	(0.00218)
D_{PH}	0.108***	(0.00143)
D_{TO}	-0.000600	(0.00150)
D_{BUS}	0.0699***	(0.00415)
$D_{BUS} * D_{TO}$	-0.00688***	(0.00185)
Constant	1.613***	(0.00318)
Observations	437755	
R^2	0.120	

The estimation is performed using GMM. The dependent variable is the daily average price per km, per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 6: Difference-in-differences regression – Frequencies group 1

	Coefficients	(Standard Errors)
D_{Monday}	0.148***	(0.00475)
$D_{Wednesday}$	-0.0298***	(0.00302)
$D_{Thursday}$	0.0953***	(0.00452)
D_{Friday}	0.284***	(0.00584)
$D_{Saturday}$	0.142***	(0.00489)
D_{Sunday}	0.331***	(0.00590)
D_{PH}	0.0548***	(0.00240)
D_{TO}	0.00874*	(0.00432)
D_{BUS}	0.230***	(0.0180)
$D_{BUS} * D_{TO}$	-0.0973***	(0.00611)
Constant	0.428***	(0.0133)
Observations	437755	
R^2	0.081	

The estimation is performed using GMM. The dependent variable is the daily average number of connections per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 7: Difference-in-differences regression – Prices group 3

	Coefficients	(Standard Errors)
D_{Monday}	0.0290***	(0.00215)
$D_{Wednesday}$	-0.000145	(0.00199)
$D_{Thursday}$	0.0132***	(0.00233)
D_{Friday}	0.0926***	(0.00372)
$D_{Saturday}$	0.0402***	(0.00303)
D_{Sunday}	0.127***	(0.00453)
D_{PH}	0.113***	(0.00302)
D_{TO}	-0.00446*	(0.00215)
D_{BUS}	0.0576***	(0.00814)
$D_{BUS} * D_{TO}$	-0.0112***	(0.00324)
Constant	1.595***	(0.00553)
Observations	63370	
R^2	0.134	

The estimation is performed using GMM. The dependent variable is the daily average price per km, per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 8: Difference-in-differences regression – Frequencies group 3

	Coefficients	(Standard Errors)
D_{Monday}	0.166***	(0.0129)
$D_{Wednesday}$	-0.0315**	(0.00966)
$D_{Thursday}$	0.124***	(0.0133)
D_{Friday}	0.448***	(0.0169)
$D_{Saturday}$	0.126***	(0.0128)
D_{Sunday}	0.512***	(0.0164)
D_{PH}	0.0721***	(0.00712)
D_{TO}	0.0127	(0.00738)
D_{BUS}	0.188***	(0.0447)
$D_{BUS} * D_{TO}$	-0.0442**	(0.0152)
Constant	0.662***	(0.0260)
Observations	63370	
R^2	0.108	

The estimation is performed using GMM. The dependent variable is the daily average number of connections per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * p < 0.05, ** p < 0.01, *** p < 0.001.

Table 9: Balanced panel regression – Prices group 1

	Coefficients	(Standard Errors)
D_{Monday}	0.0482***	(0.00126)
$D_{Wednesday}$	-0.00452***	(0.000843)
$D_{Thursday}$	0.0241***	(0.00131)
D_{Friday}	0.133***	(0.00218)
$D_{Saturday}$	0.0456***	(0.00141)
D_{Sunday}	0.199***	(0.00300)
D_{PH}	0.152***	(0.00202)
D_{TO}	-0.00563***	(0.000991)
Constant	1.681***	(0.00123)
Observations	293950	
R^2	0.241	

The estimation is performed using GMM. The dependent variable is the daily average price per km, per route and per operator, expressed in logarithms. The regression include route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 10: Balanced panel regression – Frequencies group 1

	Coefficients	(Standard Errors)
D_{Monday}	0.147***	(0.00550)
$D_{Wednesday}$	-0.0192***	(0.00273)
$D_{Thursday}$	0.108***	(0.00492)
D_{Friday}	0.212***	(0.00605)
$D_{Saturday}$	0.181***	(0.00551)
D_{Sunday}	0.209***	(0.00600)
D_{PH}	0.0153***	(0.00154)
D_{TO}	-0.0908***	(0.00398)
Constant	0.675***	(0.00414)
Observations	293950	
R^2	0.136	

The estimation is performed using GMM. The dependent variable is the daily average number of connections per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 11: Balanced panel regression – Prices group 3

	Coefficients	(Standard Errors)
D_{Monday}	0.0497***	(0.00246)
$D_{Wednesday}$	-0.00418*	(0.00202)
$D_{Thursday}$	0.0182***	(0.00271)
D_{Friday}	0.159***	(0.00541)
$D_{Saturday}$	0.0653***	(0.00361)
D_{Sunday}	0.224***	(0.00716)
D_{PH}	0.197***	(0.00456)
D_{TO}	-0.00930***	(0.00246)
Constant	1.620***	(0.00278)
Observations	36315	
R^2	0.362	

The estimation is performed using GMM. The dependent variable is the daily average price per km, per route and per operator, expressed in logarithms. The regression include route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 12: Balanced panel regression – Frequencies group 3

	Coefficients	(Standard Errors)
D_{Monday}	0.120***	(0.0165)
$D_{Wednesday}$	-0.0283*	(0.0117)
$D_{Thursday}$	0.114***	(0.0144)
D_{Friday}	0.242***	(0.0161)
$D_{Saturday}$	0.183***	(0.0151)
D_{Sunday}	0.202***	(0.0151)
D_{PH}	0.00729	(0.00375)
D_{TO}	-0.0565***	(0.0128)
Constant	0.915***	(0.0120)
Observations	36315	
R^2	0.111	

The estimation is performed using GMM. The dependent variable is the daily average number of connections per route and per operator, expressed in logarithms. The regression includes route fixed-effects. Cluster-robust standard errors (clustered on route level) are presented in parentheses. Statistics are significant for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Appendix B

Appendix B provides all proofs for Section 4.

Proof of Lemma 1. Without loss of generality, consider the segment between $l_1 = 0$ and $l_1 = \frac{1}{n}$. Given the entrant's location is $l_2 \in \left(0, \frac{1}{n}\right)$, and given any prices p_1 and p_2, the consumer who is indifferent between acquiring the service at $l_1 = 0$ and l_2 is located at $\frac{l_2}{2} - \frac{p_1 - p_2}{2tl_2}$. The ensuing demand for the entrant's outlet under consideration is thus $\frac{L}{n}\left(\frac{l_2}{2} + \frac{p_1 - p_2}{2tl_2}\right)$, which yields that outlet's profit

$$\pi_{2,l_2} = \frac{L}{n}\left(\frac{l_2}{2} + \frac{p_1 - p_2}{2tl_2}\right) p_2. \tag{3}$$

Using (3), the entrant has no incentive to move closer to $l_1 = 0$ if and only if $\frac{\partial \pi_{2,l_2}}{\partial l_2} \geq 0$, which is equivalent to

$$tl_2^2 \geq p_1 - p_2. \tag{4}$$

Substituting the entrant's optimal price $p_2(p_1, l_2) = \frac{1}{2}\left(p_1 + tl_2^2\right)$ which is obtained from the first order condition with respect to the price p_2, $\frac{\partial \pi_{2,l_2}}{\partial l_2}$ can be evaluated at $l_2 = \frac{1}{2n}$ (entry in the middle between $l_1 = 0$ and $l_1 = \frac{1}{n}$) by using (4):

$$t\left(\frac{1}{2n}\right)^2 \geq p_1 - p_2(p_1, l_2) \Leftrightarrow p_1 \leq \frac{3t}{4n_1^2}. \tag{5}$$

□

Proof of Lemma 2. Substituting $p_M = u - \left(\frac{F^2 t}{16L^2}\right)^{\frac{1}{3}}$ (see (7)) into (8) with $\epsilon \to 0$ yields

$$n_D \gtrapprox \frac{Lu - S}{F} - \left(\frac{Lt}{16F}\right)^{\frac{1}{3}} \equiv \underline{n}. \tag{6}$$

□

Proof of Proposition 1. Consider a single outlet operated by the entrant, located at l_2. There is an indifferent consumer to the left and to the right of that outlet, denoted by z and z', respectively. Given that entry occurs midway between the incumbent's outlets, there is an expected number of $\frac{L}{n}$ consumers on the respective interval, where n is the number of outlets operated by the incumbent. The entrant's profit obtained from running the store at l_2 thus reads $\frac{L}{n}(z'-z)p_2$, and the entrant's total profits are

$$\pi_2 = n\left(\frac{L}{n}(z'-z)p_2 - F\right) - S. \tag{7}$$

To determine the entrant's reaction function regarding its price consider, without loss of generality, the segment between the incumbent's outlets located at 0 and $\frac{1}{n}$. Given (4), the consumer who is indifferent between buying at $l_1 = 0$ and at $l_2 = \frac{1}{2n}$ is located at

$$z(p_1, p_2, n) = \frac{1}{4n} + \frac{n(p_2 - p_1)}{t}. \tag{8}$$

Accordingly, the consumer who is indifferent from buying at $l_2 = \frac{1}{2n}$ and $l_1 = \frac{1}{n}$ is located at

$$z'(p_1, p_2, n) = \frac{3}{4n} + \frac{n(p_1 - p_2)}{t}. \tag{9}$$

Substituting (8) and (9) into (7) gives the entrant's profits as a function of p_1, p_2 and n, from which we obtain the reaction function

$$p_2(p_1, n) = \frac{p_1}{2} + \frac{t}{8n^2}. \tag{10}$$

Substituting (10) in (8) and (9), the indifferent consumers z and z' are respectively located at

$$z(p_1, n) = \frac{3}{8n} - \frac{np_1}{2t} \tag{11}$$

and

$$z'(p_1, n) = \frac{5}{8n} + \frac{np_1}{2t}. \tag{12}$$

Substituting (10), (11) and (12) into (7) yields the entrant's profit as a function of p_1 and n. Market entry is deterred if

$$\pi_2(p_1, p_2(p_1, n), n) = \frac{L\left(4n^2 p_1 + t\right)^2}{32n^3 t} - nF - S \overset{!}{=} 0. \tag{13}$$

Rearranging (13) for p_1 gives the following solution,

$$p_1(n) = \frac{4\sqrt{2t}\sqrt{n^2 FL + LnS} - \frac{Lt}{n}}{4Ln}. \tag{14}$$

Given $p_1(n)$ in (14) full market coverage requires that $u - t\frac{1}{4n^2} - p_1(n) = 0$. The latter condition ensures that the entrant cannot enter the market by attracting those consumers who are not served by the incumbent. Rearranging that condition for n gives the number of outlets for which market entry is deterred,

$$n_D \equiv \frac{2St}{Lu^2 - 2Ft}. \tag{15}$$

By substituting n_D in (14) we obtain the ensuing price

$$p_D \equiv p_1(n_D) = u - \frac{(Lu^2 - 2Ft)^2}{16S^2 t}. \tag{16}$$

□

Proof of Corollary 1. To make the following analysis more tractable, define $\alpha := Lu^2 - 2Ft$. Note that $n_D > 0$ as defined in (11) requires $\alpha > 0$. Following Proposition 1, the entrant has no incentive to locate its outlets close to those of the incumbent if $p_D \leq \frac{3t}{(2n)^2}$, from which it follows that

$$u - \frac{a^2}{16S^2t} \leq \frac{3t}{4}\frac{\alpha^2}{4S^2t^2} \;\Leftrightarrow\; S \leq \pm\sqrt{\frac{\alpha^2}{4tu}}. \tag{17}$$

The negative solution in (17) can be ruled out due to $S > 0$. It is necessary to have $n_D \geq 1$ because otherwise the market would not exist in case of entry deterrence. Accordingly,

$$\frac{2St}{\alpha} \geq 1 \;\Leftrightarrow\; S \geq \frac{\alpha}{2t}. \tag{18}$$

Thus, the set of admissible parameter values for S is non-empty if $\sqrt{\frac{\alpha^2}{4tu}} \geq \frac{\alpha}{2t}$, i.e.,

$$t \geq u. \tag{19}$$

Next, consider the interval of admissible parameter values for S such that $n_D \geq n_M$. The latter condition requires

$$\left(\frac{Lt}{2F}\right)^{\frac{1}{3}} \leq \frac{2St}{\alpha} \;\Leftrightarrow\; S \geq \frac{\alpha}{2t}\left(\frac{Lt}{2F}\right)^{\frac{1}{3}}. \tag{20}$$

Together with (17) the interval of admissible parameter values $S \in \left[\frac{\alpha}{2t}\left(\frac{Lt}{2F}\right)^{\frac{1}{3}}, \sqrt{\frac{\alpha^2}{4tu}}\right]$ is thus non-empty if and only if

$$\frac{\alpha}{2t}\left(\frac{Lt}{2F}\right)^{\frac{1}{3}} \leq \sqrt{\frac{\alpha^2}{4tu}} \;\Leftrightarrow\; L \leq 2F\sqrt{\frac{t}{u^3}}. \tag{21}$$

As mentioned in the beginning of this proof, $\alpha > 0$ has to hold, which requires $L > \frac{2Ft}{u^2}$. Given (21) the set of admissible parameter values for L is thus non-empty if $\frac{2Ft}{u^2} < 2F\sqrt{\frac{t}{u^3}}$ which is equivalent to $t < u$. We have now arrived at a contradiction because the latter condition is inconsistent with (19).

□