Keywords: long-distance coach transport; COVID-19; random effects panel models; public sentiment; spatial Durbin model

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COVID-19 AND LONG-DISTANCE COACH SERVICES IN EUROPE: THE IMPACT OF CHANGING PASSENGER BEHAVIOR

Summary. The aim of this study is to present the consequences of the COVID-19 crisis in the long-distance coach market in Europe. Firstly, the literature review depicts the dynamic situation of European long-distance transport service providers. It is reiterated that the disruptions to long-distance coach transport triggered by the COVID-19 pandemic are multidimensional. Secondly, 10 econometric panel models, including one spatial and two dynamic panel models, were constructed for 505 or 495 regions (depending on the model) of 26 European countries. The analysis allowed us to draw conclusions about the impact of excess mortality, public sentiment, population density, and infrastructure quality on the number of long-distance FlixBus coach departures. Models indicate that increased anxiety associated with COVID-19 leads to a drop in the number of departures even when mortality anomaly is accounted for. Moreover, the number of departures changed more significantly in response to an increased infection rate in 2021 compared to 2020. This may indicate that long-distance coach companies were encouraged to implement new policies aiming at a lower frequency of trips, thereby increasing certainty that planned departures would not be canceled at the last minute. This can serve as an evidence of a shift in companies' focus towards greater flexibility of their offers.

1. INTRODUCTION

The COVID-19 crisis started when coach passenger transport in Europe was experiencing a high need for investments associated with a sustainable transport policy. Pre-crisis forecasts indicated rapid growth in the industry characterized by increased staff recruitment, investment in new vehicles, as well as the development of new innovations in electric and hydrogen vehicles and other domains, such as mobility as a service [8]. All over Europe, long-distance coach services have been strongly affected by the ban or reduction of services during lockdowns. In certain countries, despite a steady recovery in 2021 and 2022, revenues in the coach market did not fully return to their 2019 levels [6].

Right after the outbreak and during the subsequent recovery of the coach market, one could observe a switch in passengers' communication habits, resulting from the popularization of remote forms of work and leisure activities. The expansion of remote and hybrid work, the associated growth of demand for houses in suburban areas, and the popularization of multi-local lifestyles have also affected both short- and long-distance mobility. For instance, investments related to the demand for responsive transport solutions are increasing, ensuring the increased flexibility of public transport systems in low-demand areas [4]. COVID-19 has also increased the role of intermodality, promoting active modes of transport such as biking and walking, which are often neglected by public transport authorities [17].

At the same time, the COVID crisis has encouraged passenger transport companies to promote the digitalization and modernization of their processes, but it has also made them more reactive to changes

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in demand. Companies have to consider the expansion of the existing network to rural areas and optimize departure frequency. Moreover, private companies such as FlixBus and BlaBlaBus, as well as public ones, reacted to the crisis by investing in new sustainable mobility solutions, striving to enhance their brand value through cost savings and increased customer loyalty. Since COVID-19 made long-distance transport providers shift their focus towards flexibility and added value, the crisis changed the policy in this market to a more cost-effective one. Such a policy is also likely to have negative repercussions for the companies' personnel, particularly those who are sensitive to changes in working conditions and often exhausted by the constant need for adaptation. Increased driver shortages, which are more acute than they have been in decades, might be one of the consequences of such problems [12].

The disruptions caused by the COVID outbreak are also conducive to financial difficulties. In France, the public transport tax aimed at raising capital for local public transport infrastructure (the so-called v*ersement transport* tax) is expected to fall due to the pandemic. For instance, the Paris-area public transport network experienced a strong decline in monthly subscription payments in 2020 and 2021, with 75% of teleworkers canceling their subscriptions, favoring short-term tickets. Moreover, many European public service transport companies operating under net-cost contracts (where the revenue risk is borne mainly by operators or franchisees) or contracts of a concession type are endangered by periodic drops in demand [16].

One of the consequences of the crisis was the increased role of state interventionism in various domains, including public transport financing. This might constitute a challenge for private companies. For example, as a consequence of the introduction of the heavily subsidized €9 passenger ticket for regional rail passenger transport in Germany, the majority of private bus service providers experienced a significant drop (as much as 80%) in the number of passengers, according to a survey conducted by the Federal Association of German Bus Companies [15].

In short, disruptions to the long-distance coach transport triggered by the COVID-19 crisis were diverse and included the changing behavior of commuters and the necessity to adapt to it, financial difficulties, as well as increased state interventionism.

The aim of this paper is to present the consequences of the COVID-19 pandemic in the long-distance coach market in Europe, which now faces both supply and demand shocks as a result of the crisis. Firstly, the literature review will depict the dynamic situation in European long-distance passenger transport. Secondly, econometric models will be constructed in order to answer the following questions: How strongly did the degree of severity of the COVID-19 pandemic affect the number of long-distance coach departures in different periods of the pandemic in Europe? How do population density and infrastructure density affect the number of departures? What was the impact of consumer sentiments on the number of long-distance coach departures?

2. LITERATURE REVIEW

In the literature, one can find several major contributions concerning the repercussions of COVID-19 that took a toll on international and long-distance passenger transport. However, the publications concerning rail transport seem to be the most abundant. Early post-outbreak studies dealing with rail travel were often based on web based-sources. In one such study, Taczanowski [19] investigated the impact of COVID-19 on international long-distance passenger rail transport in Italy and Poland. This descriptive statistical study was based on the webpages of the Italian and Polish governments, as well as press releases and various publications of railway enthusiasts. According to the author, long-distance high-speed railway connections were more vulnerable to pandemic-related disruptions than regional ones. The latter are less prone to cancellations, possibly due to the fact that long-distance connections are more often used for business travel and, thus, were more strongly affected by the pandemic [19]. For this reason, the particular vulnerability of long-distance connections should be expected in the coach travel market as well.

An important paper by Laroche [13] explored the effect of COVID-19 on four different means of long-distance transport in France. The research was based on large panel data from the period of 2019-2021 and provided two main findings. Firstly, by the end of 2021, rail and carpooling services recovered to pre-crisis levels much faster than coach and air services. The second finding reiterated a high variability in the volume of low-cost services operations and the inflexibility of conventional services. As a consequence, by the end of 2021, the pace of recovery of low-cost services was much faster than that of conventional ones that had lost their market share [13]. One can expect analogical results regarding the situation of long-distance coach providers in the post-pandemic period.

One should also bear in mind that different modes of transport operating in the same area are interconnected. The relation between COVID-19 and the coordination level (between different modes of transport) has also been explored in the literature. Smolarski and Suszczewicz [18] analyzed the functioning of regional public transport systems in cross-border areas of the Czech Republic and Poland based on data retrieved from the websites of carriers and railway infrastructure managers. The comparison of the Polish and Czech regional public transport systems showed that the level of coordination between bus and rail transport is stronger in the Czech Republic than in Poland, which translated into a greater resistance to potential external threats such as the COVID-19 pandemic [18].

The existing literature on the impact of the pandemic on transit choice behavior confirms that increased anxiety related to the possibility of contagion might be a significant factor determining the choices of the mode of transport. Tan and Ma [20] showed that this situation arose owing to the logistic regression model of the rail transit choice based on data from a survey of 559 respondents [20]. Similar results were obtained by Aaditya and Rahul [1] using data collected from a web-based survey and integrating choice and latent variable models.

Some behavioral changes are likely to persist [14] long after the pandemic and, thus, make the recovery of passenger transport companies more difficult. Conclusions concerning the relatively slow recovery of long-distance bus travel can be drawn, for instance, from the annual reports of the French Transport Authority. They show that at the beginning of the pandemic, the demand for long-distance travel decreased by 65% and that it was not until the first quarter of 2022 that the traffic volume amounted to two-thirds of the corresponding 2019 volume. Furthermore, despite an 11% annual increase in the number of FlixBus and BlaBlaBus passengers in 2021, the number of passengers was more than two times higher before the pandemic [6]. At the same time, in France, the post-outbreak prices increased for coaches but generally decreased for other modes of transport, which might be explained by the relatively high service interruption costs sustained by long-distance transport providers [11].

The scarcity of literature dealing with long-distance coach travel, the pandemic period, the number of departures, and public sentiment stems from the difficulty in accessing accurate panel data. Apart from traffic volume measurements performed every few years and web-based surveys, the existing literature is largely based on national mobility surveys providing data on short-distance travel—for instance, to workplaces or universities. As indicated by Arbués et al. [2], examples of databases used for such research include the Spanish Statistical Office of the Ministry of Public Works, British National Travel Surveys [9], and the American National Household Travel Survey [7].

3. DATA ON LONG-DISTANCE COACH DEPARTURES

The data concerning the weekly departures of FlixBus long-distance coaches were a central part of this study. Selected descriptive statistics characterizing the number of departures in more than 700 European NUTS3 regions from March 2020 to October 2021 are presented in Table 1. The values in Table 1 are divided into clusters of countries according to the United Nations geoscheme. Departures display a high positive skewness and indicate the relative importance of Southern European destinations (especially considering seasonal trips to seaside resorts and coastal regions, leading to a high standard deviation of the results for Southern Europe). A high median number of departures to Northern Europe seems related to the small number of regions analyzed and the fact that Scandinavian countries imposed their lockdown restrictions on transport relatively late compared to the rest of Europe.

Four charts presented below (Figs. 1-4) illustrate the number of weekly long-distance bus departures (ordinate axis) in separate NUTS3 units in European countries or groups of countries (Benelux, Poland, Southern Scandinavia, and Spain). Time, ranging from Week 45 of 2019 to Week 37 of 2021, was plotted along the abscissa axis. Among these countries and regions, Spain is the only exception, with a relatively large number of departures at the end of 2021. Moreover, the charts indicate a high within-country correlation of changes in the number of weekly coach departures. We opted not to indicate the names of specific NUTS regions in the charts so as not to reveal confidential FlixBus data.

Table 1

Selected descriptive statistics concerning the number of weekly FlixBus departures

	Median	Mean	Standard deviation	Skewness
Overall	16.6	43.2	81.2	6.43
Western Europe	11.4	36.0	65.7	4.28
Eastern Europe	14.4	34.0	53.9	3.33
Northern Europe	21.7	52.2	73.4	1.93
Southern Europe	29.1	64.4	119.6	6.22

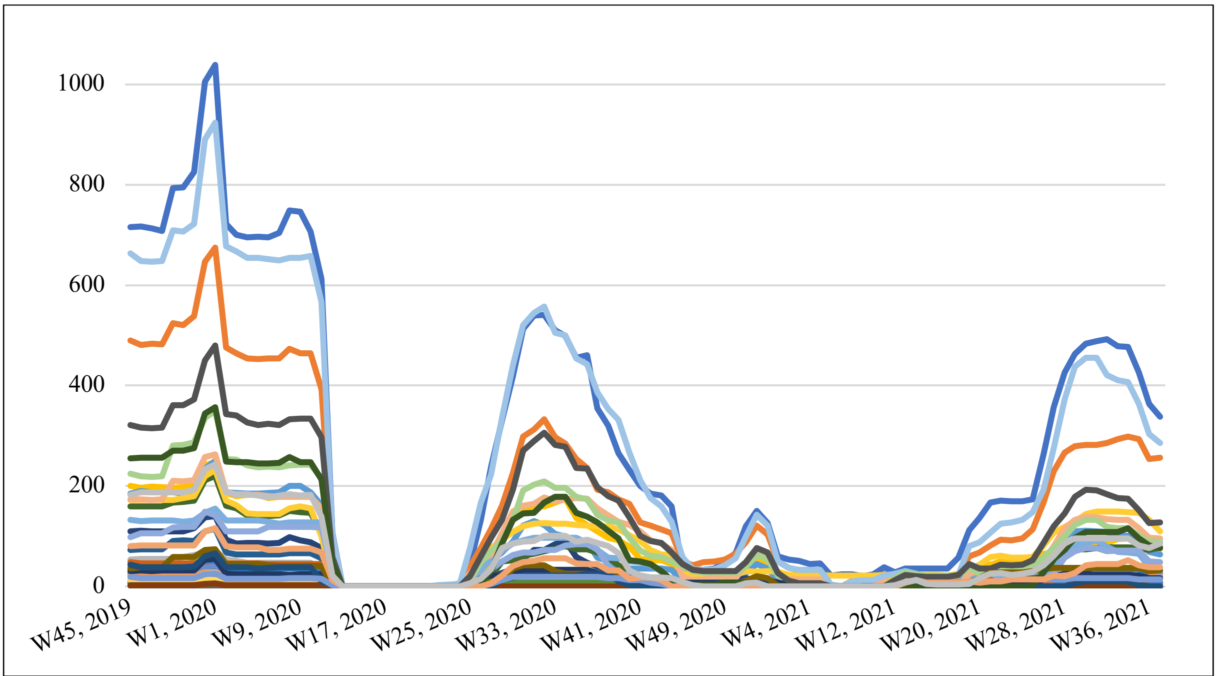

Fig. 1. Number of weekly long-distance bus departures in NUTS3 regions of Benelux

4. ECONOMETRIC MODELS: DESCRIPTION OF VARIABLES AND MODEL PROPERTIES

The present study is based on data from three different sources: the FlixBus company, Eurostat, and the SHARE database. Random effects panel models were chosen as the method of analysis. This choice was determined by the nature of the data, which will be explained more broadly in the description of each variable used in the models. Estimating pooled models would have posed a risk of making the theoretical associations between economic variables less pronounced. There were also several reasons for selecting random and not fixed effects models. Firstly, the estimation of parameters of the former takes into account not only between-group differences but also differences between values of observations in the time dimension. Secondly, fixed effects models are used more often for panels consisting of a relatively small number of units and a long testing period. Finally, independent variables can be time-invariant in random effects models. Due to the fact that group effects in random effects models are at risk of correlation with (other) regressors (and, therefore, could lead to the loss of estimator consistency), the Hausman test comparing fixed and random effects models will be performed.

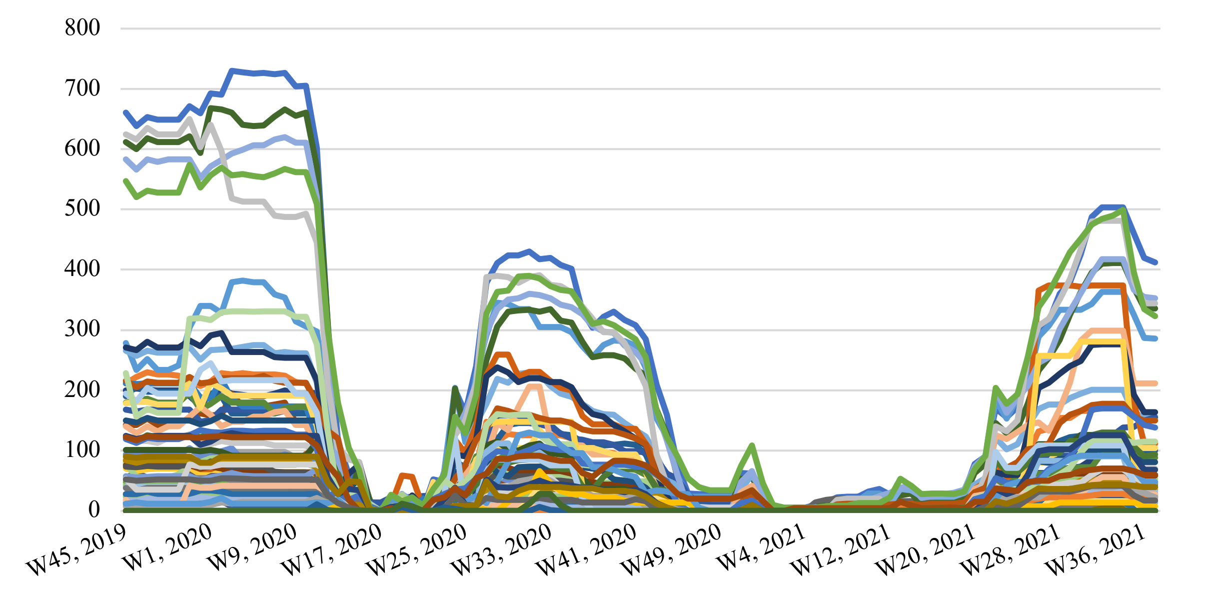

Fig. 2. Number of weekly long-distance bus departures in NUTS3 regions of Poland

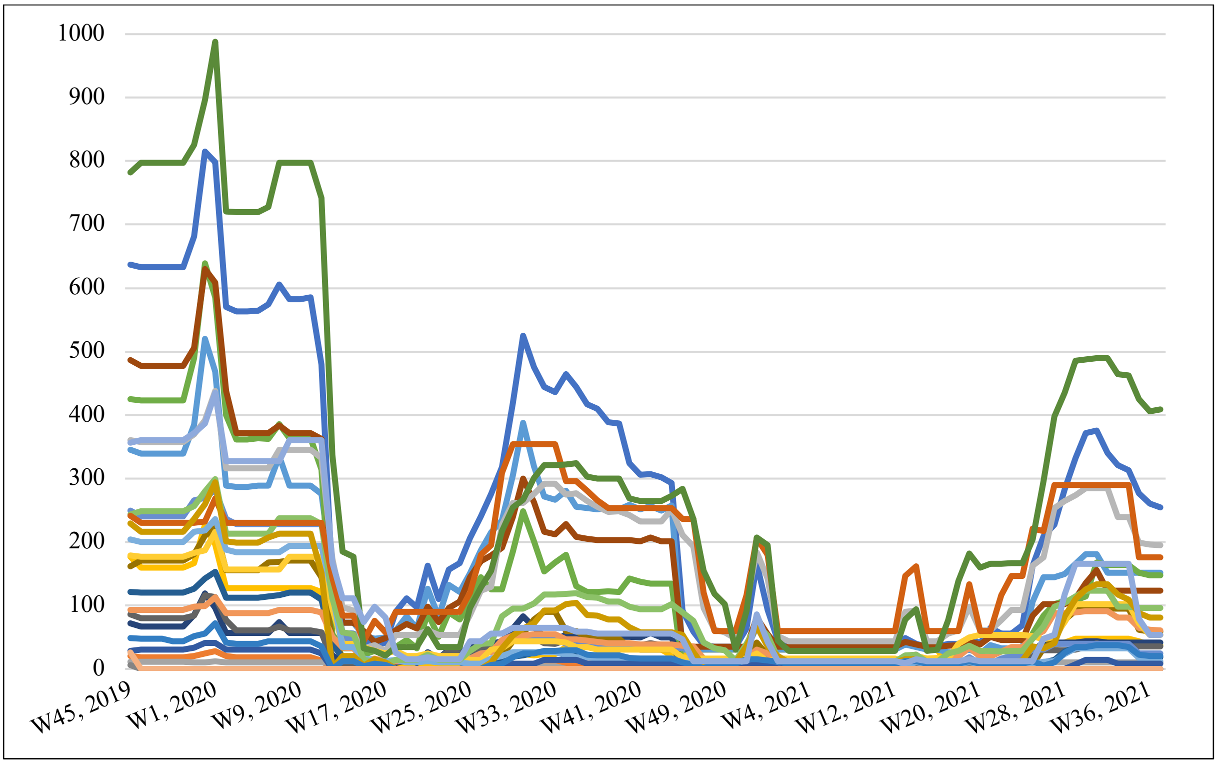

Fig. 3. Number of weekly long-distance bus departures in NUTS3 regions of Denmark, Sweden (excluding Stockholm), and Southern Norway

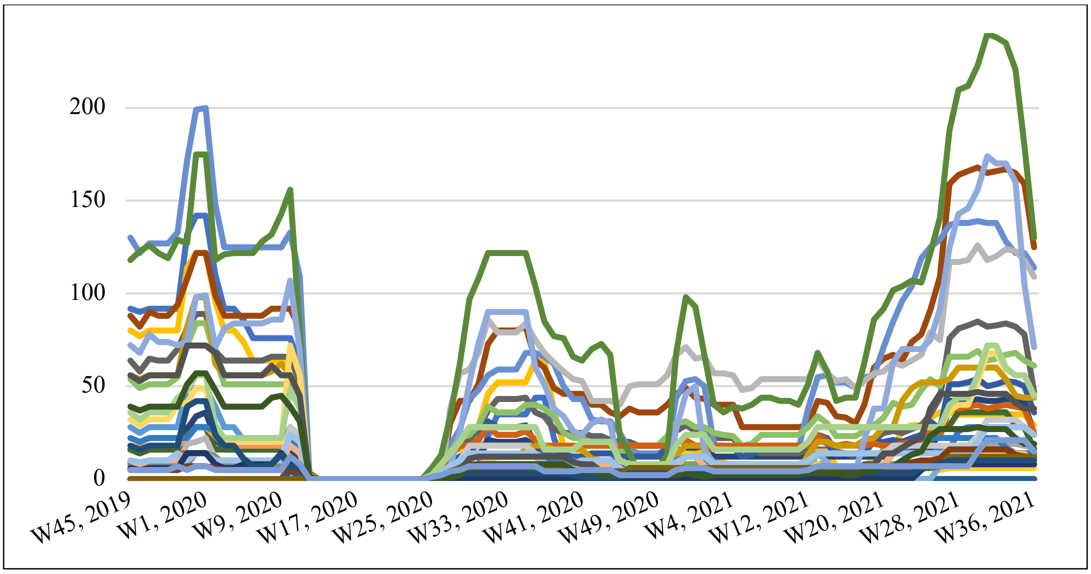

Fig. 4. Number of weekly long-distance bus departures in NUTS3 regions of Spain

Seven econometric models belonging to two types of panel models (fixed effects and random effects models) were constructed in order to draw conclusions concerning the impacts of excess mortality, population density, infrastructure quality, and public sentiment on the number of long-distance coach departures in different periods of the pandemic in Europe. Models were prepared using the STATA statistical software package. In each model, the dependent variable shows the weekly number of departures of FlixBus coaches in 505 or 459 European NUTS3 regions from the EU member states (excluding Cyprus, Estonia, Finland, Ireland, and Malta, to which there are no FlixBus connections), as well as Liechtenstein, Norway, Serbia, and Switzerland.[3] The models are of three types in terms of time dimension: models covering the period between Weeks 9 and 50 of 2020, models including the time between Week 51 of 2020 and Week 37 of 2021, and models combining two periods when the SHARE Corona 1 and Corona 2 surveys were conducted. The last time span corresponds to the time from Week 9 to 40 of 2020 and from Week 10 to 34 of 2021. This time span was slightly extended compared to the period in which the study was conducted because the survey question used to construct one of the variables described below was partly related to the period before the pandemic outbreak.

The first independent variable used in this analysis, *exc_mort*, illustrates the weekly number of excess deaths per 10,000 inhabitants of the analyzed NUTS3 regions each week from November 2019 until September 2021 compared with the average level from 2014-2019 (based on Eurostat data). In addition, this variable is shifted in time by two weeks in relation to the dependent variable in order to measure new fatal infections (two weeks is the approximate median time from the symptom onset to death in the case of COVID-19). This predictor was added to the model to represent the degree of pandemic severity.

The Eurostat database was also used to construct three other regressors. *Population* reflects the size of the population (measured in hundreds of people) in each NUTS3 region. *Pop_density* illustrates population density (persons per square kilometer). *Rail_density* shows the railway line density of 2019 in all 505 analyzed regions and was used to reflect the general density of infrastructure. It is measured as the total number of kilometers of railway lines per thousand square kilometers. These three variables are time-invariant.

The variable *anxiety_covid* is differentiated at the level of 51 regions[4] and illustrates the percentage of SHARE respondents who stated that they had felt nervous, anxious, or on edge in the month prior to

[3] The list of all 505 analyzed regions is available from the authors upon request.

[4] Regions and countries in question include Northern Bulgaria; Southern Bulgaria (Thrace, Eastern Macedonia and the Sofia Region); Flanders; Wallonia; Brussels-Capital Region; Western, Central, Northern and Southern Bohemia; Eastern Bohemia and Bohemian-Moravian Highlands; Moravia; combined NUTS2 regions of Spain

the questionnaire. This survey was conducted between June and September 2020, involving a group of more than 52,000 SHARE respondents. Fifty-one regions selected for this variable were based on 215 NUTS2 regions combined in such a way that satisfied the minimum sample size condition and reflected economic differences or historical connections. In the case of Swiss regions, as well as Wallonia and Flanders in Belgium, the language of conducting the questionnaire was used as an additional factor allowing the aggregations of NUTS2 regions into bigger ones. Values of *anxiety_covid* were set to 0 for Weeks 9-13 of 2020 in order to reflect the period when the outbreak was not yet in full swing (the earliest week concerned in the Corona 1 questionnaire was Week 14 of 2020).

Coefficients, p-values of coefficient significance tests ($P>|z|$), and R^2 statistics of random effects models are presented in Table 2. Table 3 shows the p-values of the Breusch-Pagan tests and Hausman tests and compares the coefficients of fixed effects and random effects models.

Table 2

Coefficients of non-spatial random effects panel models
(p-values of coefficient significance tests are presented in brackets)

	Model from 03-12.2020	Models from 12.2020-09.2021		Model from 03-09.2020 and 03-08.2021
exc_mort	-7.501 (0.000)	-15.888 (0.000)	-15.818 (0.000)	-8.279 (0.000)
population	0.081 (0.000)	0.063 (0.000)	0.062 (0.000)	0.009 (0.000)
rail_density	0.317 (0.000)	0.118 (0.195)		
pop_density			0.016 (0.000)	0.015 (0.001)
anxiety_covid				-0.720 (0.000)
const	-19.406 (0.013)	9.029 (0.253)	11.469 (0.04)	19.391 (0.006)
number of observations	21210	19695	19695	26163
number of regions	505	505	505	459
R2_within	0.001	0.033	0.003	0.002
R2_between	0.539	0.009	0.417	0.530
R2_overall	0.262	0.004	0.221	0.284

having a relatively high GDP per capita (Basque Country, Catalonia and the Community of Madrid); and those of the lower GDP per capita (the rest of Spain); Île-de-France; other regions of France having a relatively high GDP per capita (historical Occitania, Aquitaine, Brittany); and those of the lower GDP per capita (the rest of France); Voreia Ellada Region (Epirus, Macedonia, Thrace); the rest of Greece; the former Continental Croatia NUTS2 region; Adriatic Croatia; Budapest and Pest County; the rest of Hungary; Northern Italy (including Tuscany and Emilia-Romagna); Central Italy (including Abruzzo); Southern Italy (including Sardinia); Vilnius County; the rest of Lithuania; Luxembourg; Latvia; Eastern Poland (including voivodeships from the Eastern Poland Operational Program of 2014-2020); Central Poland (encompassing three central voivodeships with the three biggest Polish cities); Silesia; North-Western Poland; Alentejo, Algavare, The Lisbon Metropolitan Area; Central and Northern Portugal; Transylvania (understood broadly as the part of Romania that fell under Austro-Hungarian Empire in the 19th century); Bucharest Region; Wallachia, Dobruja, Western Moldova; Eastern Sweden; Northern Sweden; Southern Sweden; Eastern Slovenia; Western Slovenia; Bratislava and Western Slovakia NUTS2 regions combined; Central Slovakia; Eastern Slovakia; Romandy; the German-speaking part of Switzerland excluding Upper Valais; Ticino Region; the former German Democratic Republic and Berlin; the northern part of the former Federal Republic of Germany (Rhineland, Saarland, Schleswig-Holstein, Lower Saxony); the southern part of the former Federal Republic (Hesse, Bavaria, Baden-Württemberg); Eastern Denmark (Zealand, Lolland, Bornholm); and the rest of Denmark (Jutland, Funen).

Table 3

P-values of Breusch-Pagan tests and Hausman tests comparing the exc_mort coefficients of non-spatial fixed effects and random effects models

	Models from 03-12.2020	Models from 12.2020-09.2021		Models from 03-09.2020 and 03-08.2021
		Model with *rail_density*	Model with *pop_density*	
Breuch-Pagan test for random effects	0	0	0	0
Hausman test comparing exc_mort coefficients	0.345	0.826	0.626	0.468

In the fixed effects models, systematic and one-sided deviations of the number of departures estimated by the model against the actual number of departures occurred in the regions with the highest populations (especially in country capitals). Therefore, random effects models containing the *population* variable may be resistant to some disturbances, which was also indicated by the Hausman test comparing the coefficients for the variable *exc_mort*. The *population* variable could not be added to the fixed effects model due to the high collinearity stemming from its time-invariance. Furthermore, the Hausman test indicated that random effects models are better suited to data. Specifically, in the case in which there is one version of the random effects model for the period of December 2020 to September 2021, the variable *rail_density* was not significant. Therefore, it was switched with the *pop_density* in the next model. The latter variable should be used to draw conclusions about this time period. Breusch-Pagan tests for random effects suggest that in all cases, pooled models were less fitted to empirical data than random effects models.

It should be noted that the standard deviation of the region-specific effect (region-specific error component) in the random effects model for the combined time period was 116.6, while the standard deviation of the idiosyncratic disturbance (varying across time and NUTS3 regions) was 162.3. Consequently, the value of the fraction of total variance due to region-specific effects was relatively low (34.1%), whereas the fraction explained by the idiosyncratic error term amounted to 65.9%.

It was also considered whether the addition of *population* and *pop_density* variables in the same model was conducive to regressor endogeneity. Thus, two random effects models containing these variables were scrutinized: the model from the period of December 2020 to September 2021 and the model from the combined period of Corona surveys. Initially, for these two periods, Pearson's correlation coefficients between *population* and *pop_density* were relatively low (13.5% and 12.9%, respectively). Moreover, for each of the two tested models, generalized two-stage least squares random effects instrumental variable (G2SLS RE IV) regression was estimated with *rail_density* as an instrument of *pop_density* (especially suspected as being the source endogeneity). A comparison of the random effects regressions with the modified (G2SLS RE IV) ones indicated that there are no systematic differences between coefficients in these two types of models. Moreover, the Hausman test showed that there was no ground to reject the null hypothesis about the consistency of the *pop_density* estimator in the original (non-restricted, higher-efficiency) models. For the two suspected models, the p-values of the Hausman tests were 0.897 and 0.410, respectively. Both instrumental variable models passed the strong identification checks carried out using the *xtoverid* Stata command, as the Cragg-Donald statistic was equal to 2578 and 3356, respectively. The reason for the possible and assumed lack of endogeneity bias stemming from the association between *population* and *pop_density* (and between the dependent variable and *pop_density*) revolves around their time invariance and the specific delimitation of the NUTS3 regions based on the assumption that the units have to be similar in terms of population, resulting in relatively bigger regions in less densely populated areas.

Additionally, White's robust estimation was performed in order to check whether the standard errors of the previous estimation would increase. It turned out that the increase was minor, and the conclusion about the statistical significance of variables did not change. Therefore, we opted to report only the statistics presented in Table 2. Similarly, estimating models containing robust standard errors clustered by countries (and the ones clustered by separate regions) did not result in the loss of the significance of regressors at the significance level of 0.05. Moreover, Wooldridge's tests for unobserved effects indicated that there are no grounds for rejecting the null hypothesis about the lack of unobserved individual effects at the level of significance of 0.01.

The cross-sectional independence was considered by performing Pesaran's test. The test's statistic, which amounted to 1120.3 in the case of the random effects model from the period of two SHARE Corona surveys, indicated that the problem of cross-sectional dependence might be present.

Due to the inclusion of time-invariant variables and a rather small number of observations in the time dimension, the spatial Durbin panel random effects model (and not, for instance, the Driscoll and Kraay's spatial correlation consistent estimation [10]) was selected to check the severity of the implications of the potential problem. It was calculated using the standardized inverse-distance weighting matrix (for the distances between centroids) and concerned the combined period of two Corona surveys. The set of variables was slightly different—*pop_density* was replaced with the similar *rail_density* variable. Additionally, the time variable was included in the spatial panel model in order to check the importance of an additional assumption—that there is a trend in the number of departures, which is separate from the variation of other predictors (partly associated with external factors such as the changing company's policy). *Excess_mortality* and *anxiety_covid* were selected as spatially lagged variables. Despite the slightly different specifications, the values of estimated coefficients remained roughly similar to the values indicated by the non-spatial panel model from the combined period of March to September 2020 and March to August 2021. It should be noted that the higher value of information criteria indicated that the fit to empirical data of the simple panel model was slightly worse than the spatial model's fit despite the more parsimonious specification of the former. The main results related to the spatial model are presented in Table 4.

Table 4

Coefficients of the spatial Durbin random effects panel model
(p-values of coefficient significance tests are presented in brackets)

	Model from the combined period of 03-09.2020 and 03-08.2021
exc_mort (spatially lagged)	-8.056 (0.050)
population	0.009 (0.000)
rail_density	0.216 (0.035)
anxiety_covid (spatially lagged)	-0.700 (0.000)
time (week)	0.325 (0.001)
rho (spatial autoregressive parameter)	0.909 (0.000)
const	-67.724 (0.000)
number of observations	26163
number of regions	459
R2_within	0.0875
R2_between	0.5186
R2_overall	0.3163

In order to check the robustness of the results in the presence of potential endogeneity, difference [3] and system [5] generalized method of moments (GMM) dynamic panel models were computed as well. Given that the panel is relatively wide and short, the instrument matrix was curtailed and collapsed. Such additional models allowed for autocorrelation tests. Arellano-Bond serial autocorrelation tests indicated an expected first-order autocorrelation of residuals (associated with the model construction) but no autocorrelation for higher orders at the significance level of 0.001. Sargan overidentification tests indicated that curtailing (removing higher order lags[5]) and collapsing (taking linear combinations of instruments) were needed to ensure the model's validity. The results obtained in the estimation of dynamic panel models are presented in Table 5. Importantly, the sign of the *exc_mort* coefficient was roughly consistent with that of non-dynamic models.

Table 5

Coefficients of the system GMM panel models
(p-values of coefficient significance tests are presented in brackets)

	Model from the combined period of 03-09.2020 and 03-08.2021	
	Model after curtailing	Model after curtailing and collapsing
exc_mort	-17.390 (0.000)	-6.223 (0.000)
departures (lagged)	0.979 (0.000)	0.917 (0.000)
const	5.960 (0.000)	5.926 (0.000)
number of observations	24327	24327
number of regions	505	505

5. RESULTS

The values of the coefficients of the *exc_mort* variable in different models indicate that the mortality anomaly greater than one death per 10,000 inhabitants is associated with a decrease of approximately 7.4-15.9 long-distance departures in a given week in an average NUTS3 region, *ceteris paribus*. One important result stemming from the comparison of models from different periods is that the impact of the pandemic, measured based on excess mortality, is around two times higher in the latter period but not the earlier period. This may be unsurprising considering the lower lethality of COVID-19 connected with the wide distribution of vaccines and, for instance, the development of antiviral drugs (more infections contribute to a given mortality anomaly in later periods). In 26 analyzed countries, the COVID death rate (lethality) dropped from 2.28% in the earlier analyzed period to 1.79% in the later period (based on the Our World in Data database). Even after taking into account this change, the stronger reaction of the number of departures to excess mortality remains significant. Owing to these statistics, coefficients for the *exc_mort* variable can be converted into approximate percentages of people infected with SARS-CoV-2. Between February and December 2020, each new infection per 100 inhabitants in a given week was connected with 17.1 fewer weekly departures on average, whereas in the period of December 2020 to September 2021, a similar increase in the infection rate was responsible for a more significant decline in the number of weekly FlixBus departures in a given NUTS3 region, amounting to 28.3 departures, *ceteris paribus*. The relatively low frequency of trips at the end of 2021 made by FlixBus buses can also be seen in the four charts presented in the third section of this study [Figs. 1-4].

Positive signs of *population*, *pop_density*, and *rail_density* variables indicate that a larger population, as well as a larger population density and infrastructure density, are associated with more intercity departures in a given week, *ceteris paribus*. This might be due to the relative importance (for instance, country-capital status) of particular NUTS3 regions, the higher demand for business travel, and the greater intensity of departures related to students traveling to universities from their hometowns. The results show that an increase in the population of a given region by 10,000 people aligns with approximately one more weekly departure of intercity buses. Moreover, a higher population density of

[5] The maximum order for the autoregressive specification was set to four.

100 citizens per square kilometer is associated with an increase in the number of weekly FlixBus departures of approximately 1.6, *ceteris paribus*. According to the significant coefficient of *rail_density*, an increase of 10 kilometers per thousand square kilometers in a given NUTS3 region is associated, *ceteris paribus*, with an increase in the number of weekly departures of 3.2.[6]

The results related to the *anxiety_covid* variable provide evidence that if the proportion of people who subjectively consider themselves as nervous, anxious, or on edge due to COVID-19 (among all citizens) is increased by five percentage points, coach service providers should be prepared for a decrease in the demand leading to a drop in the number of departures, amounting to 3.6 fewer departures on a weekly basis, even when the excess mortality is already taken into consideration. This shows that objective measures related to the severity of the pandemic may affect the demand (and, consequently, the supply) in this market are of importance, as are subjective perceptions specific to a given region related to its culture and mentality.

The process of constructing the *anxiety_covid* variable allowed us to create a map [Fig. 5] derived from the SHARE Corona 1 survey. The map covers regions of four countries not included in the panel analysis due to the lack of FlixBus connections: Cyprus, Estonia, Finland, and Malta. Due to the mixed linguistic structure of the Swiss region of the Espace Mittelland NUTS2 region, the percentage ascribed to this region was based on the percentages of the French-speaking and German-speaking populations. In the panel analysis, the values corresponding to NUTS3 units from this region were assigned appropriate percentages depending on the linguistically prevailing population and were not averaged as in the map.

Taking into consideration data about new COVID-19 cases, the map [Fig. 5] indicates that respondents from regions with a higher percentage of new cases were more concerned by the situation compared to regions with a lower percentage of new cases. However, there were several exceptions—for example, Lithuanians (and, to a lesser extent, Latvians) were relatively highly concerned about the situation during the first period, even though the number of cases declared in this country was relatively low at that time. Furthermore, data about the later period from the SHARE Corona 2 survey also allows us to conclude that the inhabitants of some regions felt slightly more or slightly less anxious, nervous, or on edge about the pandemic situation than the data on the number of new cases would indicate. For instance, in the period of March to August 2021, Swedes (and, to a lesser extent, Germans and Czechs) stood out as particularly unconcerned by the pandemic situation.

6. LIMITATIONS AND DISCUSSION

One of the major limitations of the models for the earlier time period and the combined one is the fact that setting a specific length of the pre-pandemic period in the analysis (allowing a comparison of periods before and after the outbreak) is arbitrary; lengthening or shortening would slightly change the values of the coefficients. The adoption of Week 9 as the starting observation in econometric models was based on the availability of data about long-distance coach departures.

Another caveat is related to inaccuracies concerning the unavailability of answers in the SHARE survey at the level of NUTS3 units (used for all variables apart from *anxiety_covid*). Moreover, acquiring information at the level of NUTS2 units (or NUTS1 units in the case of Germany) reduces the number of respondents, as questions concerning the place of residence of respondents were posed in early editions of the SHARE questionnaire but not in the Corona 1 or Corona 2 surveys.[7]

Moreover, one should bear in mind that the SHARE questionnaire mainly concerns people aged 50 and above. Participation rates in the intercity coach transport of such people are quite low. For instance, according to the American National Household Travel Survey, in 2003, the participation rate in long-distance travel of people aged 65 and above amounted to only 8% [7]. Nevertheless, we assume that the

[6] Own elaboration based on data from Eurostat.

[7] The information about the region of residence was retrieved partly from the Retrospective Accommodation module from the SHARELIFE interview section (the question code was RA015_acountry) and partly from the information on the NUTS codes from the gv_housing module.

level of nervousness or anxiety (associated with the pandemic) of middle-aged and older citizens should reflect, to some extent, the analogical level experienced by the average customer of long-distance carriers.

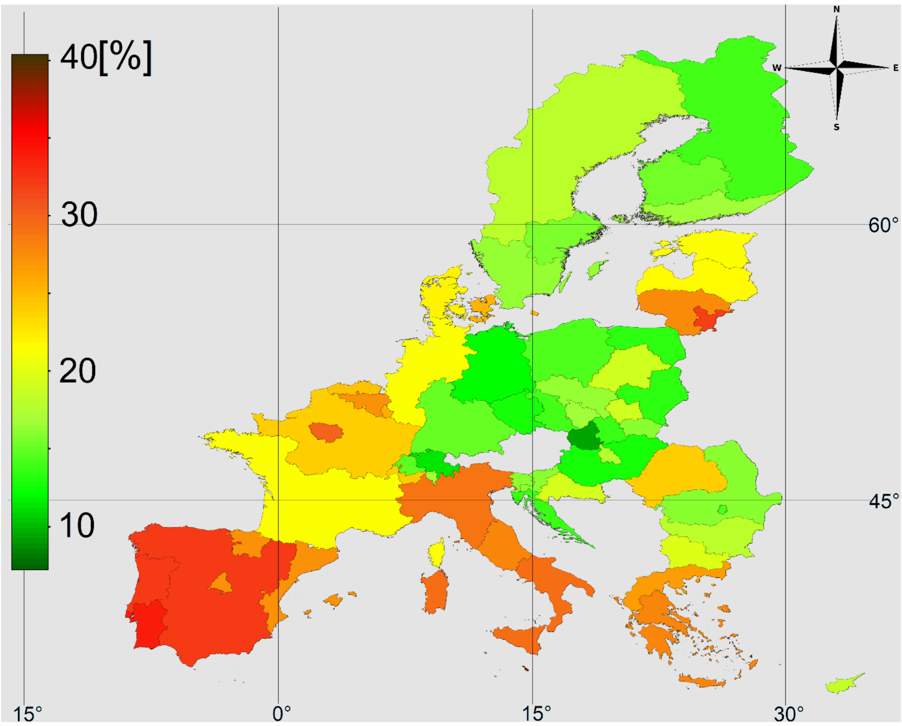

Fig. 5. Percentage of respondents stating they had felt more nervous, anxious, or on edge than before the pandemic outbreak (the question concerned respondents' sentiments in the month prior to the questionnaire conducted between June and September 2020). Note that the Mercator map projection was used and that the regions not covered by the analysis have been grayed out

Regarding the conclusion related to the stronger reaction of the number of departures to new infections in 2021 compared to 2020, the results seem baffling, as potential customers should become increasingly used to the pandemic situation and, thus (at least slightly) less responsive to new COVID waves. The Oxford Stringency Index shows that European governments' responses to the fourth wave of the pandemic, in comparison to the number of new infections, was, on average, lighter than that during the first two waves (according to the Our World in Data database). In looking for an explanation, one may consider the impact that the introduction of new COVID passports had on the number of departures. Nevertheless, due to a high discrepancy between the strength of the reaction in the two periods in question, a more flexible reaction to the pandemic may underlie the specific company's policy aiming at a lower frequency of trips ensuring a greater certainty that the planned departures will not be canceled at the last minute by new restrictions (the results do not allow for firm statements on the company's policy). The possible switch in a company's policy seems to constitute an empirical backup for the suspected shift in the focus of long-distance transport service providers who invested in new lean management solutions, as mentioned in the Introduction section.

Regarding the association between new infections and the level of anxiety related to the pandemic (indicated in Fig. 5), the deviation from the norm in certain countries (mentioned in the Results section) strengthens the conclusion that the demand for long-distance coach transport may have changed in different ways in certain countries despite their similar percentages of new cases due to differences in public sentiment. A similar result was obtained in the econometric analysis. The fear of contagion or other forms of anxiety influencing commuters' behaviors seems to constitute a significant factor influencing the number of long-distance bus departures.

7. CONCLUSIONS

To conclude, disruptions to long-distance coach services associated with the COVID-19 pandemic were multidimensional, including the high need to be more flexible in adjusting the supply to changing demand, the increased difficulty in recruiting new drivers, the necessity to adjust to the new role of intermodality and state interventionism, and the difficulty in maintaining financial stability. Some of the changes in consumer behavior are likely to persist long after the crisis. One can also observe that the drop in the number of commuters is likely to be persistent, which might be connected to the change in the strategies of long-distance transport providers.

The findings indicate that an increase in the mortality anomaly of one death per 10,000 inhabitants is associated with approximately 7.4-15.9 fewer long-distance FlixBus departures in a given week in an average NUTS3 region, *ceteris paribus*. Similarly, between February and December 2020, each new infection per 100 inhabitants in a given week correlated with an average of 17.1 fewer weekly departures, whereas, in the period of December 2020 to September 2021, a similar increase in the infection rate was responsible for a more significant decline in the number of weekly departures in a given region (28.3 departures on average), *ceteris paribus*. The impact of the pandemic, measured as the excess mortality and the percentage of new infections, is around two times higher in the later period but not the earlier period. Furthermore, the stronger reaction of the number of departures to excess mortality remains significant even after the differences in lethality in different periods of the pandemic are taken into account. This may be explained by a more flexible reaction of long-distance transport providers to the pandemic, which may be related to each specific company's policy aiming at a lower frequency of trips to ensure a greater certainty that the planned departures will not be canceled at the last minute.

Furthermore, a larger population, population density, and railway network density are associated with more intercity departures in a given week. This might be due to the relative importance (for instance, the country-capital status) of particular regions or cities, a higher demand for business travel, and a greater intensity of departures related to students traveling to universities from their hometowns.

Finally, when the proportion of people who subjectively consider themselves nervous, anxious, or on edge due to COVID-19 is increased by five percentage points, coach service providers should be prepared for a decrease in demand leading to a drop in the number of departures (3.6 fewer departures per week, *ceteris paribus*, should be expected). The particular importance of public sentiment can also be seen in the discrepancy between the level of anxiety and nervousness related to COVID-19 perceived by citizens of different European countries and the more objective level of excess mortality.

References

1. Aaditya, B. & Rahul, T. Psychological impacts of COVID-19 pandemic on the modechoice behaviour: A hybrid choice modelling approach. *Transport Policy*. 2021. Vol. 108. P. 47-58.
2. Arbués, P. & Baños-Pino, J. & Mayor, M. & Suárez, P. Econometric modeling of long-distance domestic travel. *Revista de Economia Mundial*. 2014. Vol. 38. No. 4. P. 101-126.
3. Arellano, M. & Bond, S. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies*. 1991. Vol. 58. No. 2. P. 277-297.
4. Berselli, D. & Chirca, M. & Cristea, L. & Escudero, J.C. & Estrada, M. & Faria, A. & Geier, T. & Jofre, M. & Mallia, L.S. & Martins, R. & Milne, J. & Mladenovic, M. & Nadal, M. & Rapacz, P. & Moiso, D.R. & Signor, L. & Wessing, U. Demand Responsive Transport: Recommendations for Successful Deployment. *Urban Mobility Next*. 2022. Vol. 7. P. 1-36. Available at: https://www.eiturbanmobility.eu/wp-content/uploads/2022/10/EIT-UrbanMobilityNext7.pdf.
5. Blundell, R. & Bond, S. Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*. 1998. Vol. 87. No. 1. P. 115-143.
6. Chauveau, E. & Judith, C. & Lai, A. & Lepetit, Q. & Le Potier, A. & Rouault, J. & Vacaru, I. *Rapport annuel sur le marché du transport par autocar et sur les gares routières en 2021*. Paris. Autorité de

régulation des transports. 2022. [In French: *Annual report on the coach transport market and bus stations in 2021*. Paris. Transport Regulatory Authority].
7. Collia, D. & Sharp, J. & Giesbrecht, L. The 2001 National Household Travel Survey: a look into the travel patterns of older Americans. *Journal of Safety Research*. 2003. Vol. 34. No. 4. P. 461-470.
8. Crozet, Y. & Santos, G. & Coldefy, J. *La régulation de la mobilité urbaine à l'épreuve de la mobilité partagée et du « MaaS »*. Brussels: Centre on Regulation in Europe. 2019 [In French: *The regulation of urban mobility put to the test of shared mobility and "MaaS"*. Brussels: Centre on Regulation in Europe].
9. Dargay, J. & Clark, S. The determinants of long distance travel in Great Britain. *Transportation Research Part A: Policy and Practice*. 2012. Vol. 46. No. 3. P. 576-587.
10. Driscoll, J.C. & Kraay, A.C. Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data. *The Review of Economics and Statistics*. 1998. Vol. 80. No. 4. P. 549-560.
11. Guihéry, L. Long Distance Coach Services in France and Germany: the new European competition between Flixbus and BlaBlaBus. *Rivista di Economia e Politica dei Trasporti*. 2019. Vol. 1. P. 1-12.
12. *Tackling Driver Shortage in Europe. International Road Transport Union Report*. Geneva: International Road Transport Union. 2019. Available at: https://transport-online.de/sites/default/files/public/data-news/tackling-european-driver-shortage-iru-report.pdf.
13. Laroche, F. The effect of COVID-19 on long-distance transport services in France. *Regional Science Policy and Practice*. 2022. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9115494/.
14. Murray, K. & Häubl, G. Explaining Cognitive Lock-In: The Role of Skill-Based Habits of Use in Consumer Choice. *Journal of Consumer Research*. 2007. Vol. 34. No. 1. P. 77-88.
15. Neuman, K. & Dreier, T. & Strohkirch, M. *Konjunkturumfrage 2021/2022*. Berlin: Bundesverband Deutscher Omnibusunternehmen. 2022. [In German: *Business Survey 2021/2022*. Berlin: Federal Association of German Bus Companies].
16. *Rapports financiers 2020*. Issy-les-Moulineaux: Transdev. 2021. Available at: https://www.transdev.com/wp-content/uploads/2020/03/transdev-group-rapport-financier-2019-version-francaise.pdf. [In French: *Fiancial Reports 2020*. Issy-les-Moulineaux: Transdev].
17. Shaer, A. & Haghshenas, H., 2021. Evaluating the effects of the COVID-19 outbreak on the older adults' travel mode choices. *Transport Policy*. 2021. Vol. 112. P. 162-172.
18. Smolarski, M. & Suszczewicz, M. Wpływ pandemii COVID-19 na funkcjonowanie regionalnego transportu kolejowego obszarów przygranicznych – na przykładzie województwa dolnośląskiego (PL) i kraju libreckiego (CZ). *Czasopismo Geograficzne*. 2021. Vol. 92. No. 1. 121-140. [In Polish: The Impact of the Covid-19 Pandemic on the Operation of Regional Rail Transport in Border Areas – On The Example of Lower Silesia (PL) and Liberec Region (CZ). *Geographical Journal*].
19. Taczanowski, J. The influence of COVID-19 on international and long-distance passenger rail transport. The cases of Italy and Poland – the first observations. *Prace Komisji Geografii Komunikacji*. 2020. Vol. 23. No. 2. P. 14-19.
20. Tan, L. & Ma, C. Choice behavior of commuters' rail transit mode during the COVID-19 pandemic based on logistic model. *Journal of Traffic and Transportation Engineering*. 2021. Vol. 8. No. 2. P. 186-195.

Received 12.05.2022; accepted in revised form 04.09.2023